JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 31 AUGUST —, 1950 No. 3

THE ADRENO-PITUITARY SYSTEM AND POPULATION CYCLES IN MAMMALS

BY JOHN J. CHRISTIAN

Since Elton (1924) published his first account of population cycles, there has been a tremendous amount of work done to determine what animals have cyclic fluctuations and what causes these fluctuations to occur with such regularity. Hatt (1930) and Hamilton (1937) both reviewed and discussed vole fluctuations at length. Elton later (1942) reviewed the whole subject in detail. In 1948 Rowan described the ten-year cycle as seen in central Canada with particular reference to snowshoe hares and grouse. Most recently Clarke (1949) briefly summarized the present status of the subject. One thing is abundantly clear in all of these discussions: the cause of cyclic population fluctuations remains unknown. The number of species now known to cycle are legion, in fact the non-cyclic mammal is the exception rather than the rule. The problem of the sudden die-off following a population peak appears to be a major key to the whole problem. Similarly, it has become increasingly clear that infectious diseases or parasites are not the primary factor causing these die-offs. Thus in any explanation of mammalian cycles, we are faced with the problems of accounting for the population-wide sudden death, which has no easily apparent cause, and the fixed cycle length of each species with its attendant population increase during this period.

Since intensive investigations into mammalian cycles began, there have been discoveries in many fields which now appear to be of importance in explaining cyclic phenomena. Selye (1946) elucidated the role of the adreno-pituitary system of the individual in response to stress, and described the diseases resulting from the derailment of this mechanism. The concepts of territoriality and home range have been applied to mammals (Burt, 1940; 1943) and will obviously have a bearing on mammalian populations. The vital statistics of many localized populations have been worked out for varying lengths of time. Lastly, there has been considerable work done on reproduction in mammals, especially with reference to environmental factors influencing the annual reproductive cycle. All of these will be dealt with at greater length later. It now seems that sufficient information is at hand to postulate an explanation of mammalian cycles, although many details will still remain to be worked out.

Although it may seem reversed, I am starting at the end of the cycle, because the die-off is its most startling phenomenon as well as one of the major problems to be explained. This crash has been sufficiently described by Elton (1942) to make unnecessary any further description of its general aspects here. Suffice it to say that the crash occurs following a peak in the population, and terminates a cycle of increasing abundance. More detailed accounts of several investigations on crashes are given below.

In 1909 Piper described an outbreak and subsequent die-off of meadow voles (*Microtus montanus*) in Nevada. The peak was reached in the winter of 1907–08, and was followed by the crash from January to March of 1908. All attempts to relate the die-off to a causative organism failed.

Elton, Ford, Baker, and Gardner (1931) intensively investigated a predicted crash in *Apodemus sylvaticus* in late winter and early spring, and were wholly unable to demonstrate any causative organism. No recognizable pathological lesions were demonstrated. These authors did not definitely rule out the possibility of a virus infection, but they believed it extremely unlikely on the basis of negative lesion findings. Their conclusion was "that some obscure biochemical or psychological condition of the mouse population caused the animals to die in captivity (after being brought in from the wild) with the most unusual regularity and rapidity." Animals brought in to the laboratory died within a day or so under identical conditions to those previously kept for three weeks or more. They state that something was at work in the mouse population that was able, either without shock or stress of the mice being trapped and brought into captivity, or with the aid of these factors, to destroy the mice extremely quickly, and before any important lesions had developed. They assume that the mice were weakened by some factor the investigation did not reveal. These authors describe one *Microtus* dying in convulsions, this species having experienced a crash similar to *Apodemus*. No lesions could be found in the brain or elsewhere in this animal.

Findlay and Middleton (1934) definitely ruled out bacteria and viruses as causative agents during a die-off of *Microtus agrestis*. Preceding death in these animals there was a lethargic period followed by a period of convulsive activity. The mice "exhibited head retraction, circular movements, hunching of the back, and frequently paralysis of the hind limbs associated with periodic convulsive movements. Sometimes sudden death occurred during these convulsions, more commonly the voles passed into a comatose condition, followed after a short period by death." Cysts of *Toxoplasma* were found in the brains of 19 out of 34 voles in sufficiently good condition for careful examination. This organism is quite widespread normally, and occurred here in little over half of the animals that died. It hardly seems probable in view of other authors' findings that *Toxoplasma* can be seriously considered as the prime cause of decimation in the voles. The salient fact is that here again are animals dying without demonstrable cause.

Hamilton (1937) studied *Microtus pennsylvanicus* populations in the region of Ithaca, New York, from 1924 to 1936, with intensive work from the spring of

1933 to the fall of 1936. Over 4000 animals were examined during this time. A population high was recorded in the winter of 1935–36, and was followed by a period of marked mortality from March to June 1936. Hamilton assumed that disease was the paramount factor in reducing the spring population, and points out that epidemiologically ideal conditions existed for the spread of disease during a population peak. Animals of all ages were affected. The symptoms found in the dying mice were sluggishness, ruffled fur, and lethargy. After incipient drowsiness, a characteristic spasmodic twitching of the neck and shoulders occurred with the animal falling on its side. The animals finally died in convulsions after preliminary extension of the hind legs. These symptoms are remarkably like those described by Findlay and Middleton above. Laboratory examinations of mice dying in convulsions revealed no pathological lesions, nor could a causative organism be demonstrated. Again a filtrable virus could not be definitely ruled out. Brain examinations were completely negative. External parasites were extremely abundant, but Elton (1942) has shown that this is the result of the increased age of the animals which have wintered over from the preceding fall. Once again we have the deaths unexplained.

Green and his co-workers (1938*a*, 1938*b*, 1939), during an intensive study of the periodic die-off in snowshoe hares in Minnesota, were able to demonstrate that a very small number of deaths could be attributed to infectious disease. The majority of the animals exhibited a characteristic syndrome which the authors have termed "shock disease." This syndrome was characterized primarily by fatty degeneration and atrophy of the liver with a coincident striking decrease in liver glycogen and a hypoglycemia preceding death. Petechial or ecchymotic brain hemorrhages, and congestion and hemorrhage of the adrenals, thyroid, and kidneys were frequent findings in a smaller number of animals. The hares characteristically died in convulsive seizures with sudden onset, running movements, hind-leg extension, retraction of the head and neck, and sudden leaps with clonic seizures upon alighting. Other animals were typically lethargic or comatose. Some showed a combination of these two states. The similarity of these symptoms, and those of the mice above, to those of hypoglycemic convulsions is notable. Best and Taylor (1939) give the following description of the symptoms of hypoglycemia produced by any means: "The signs and symptoms vary in the different species. The first signs in the rabbit are hyperexcitability and desire for food. The excitability becomes greater, and mild, and then severe, convulsions are exhibited. The head is retracted and the hind limbs extended in the intervals between convulsive seizures. Coma is frequent. The animals may exhibit rigor mortis immediately after death. The signs in dogs are quite similar. Mice, in some instances, may become comatose without exhibiting convulsions."

In these hares the NPN rose progressively as the symptoms developed with uremia being found in some. These authors (Green *et al.*) emphasized the inability of the animals to withstand any undo exertion or stress which would leave normal animals unaffected. These findings were demonstrated equally in all hares older than seven weeks, and this is of importance, since it shows

that factors which induce shock disease exert sufficient influence to produce deaths in both young and old animals in nature. The population studied reached its peak in 1933, and the decline was continuous until 1937, with the greatest die-off being in the fall and winter of 1935. Similar observations were made in the northern United States and central Manitoba. The conclusions reached were that shock disease is primarily responsible for decimations of snowshoe hares, that local conditions were attributable, and that severe upsets in carbohydrate metabolism were the primary effect on the hares.

Throughout these various investigations there is a remarkable consistency in the findings, regardless of the species. With the possible exception of Findlay and Middleton's *Toxoplasma* infections no pathogenic organisms could be demonstrated. The onset of symptoms, terminating in convulsions, shows a similar pattern in every case, and all would appear to be hypoglycemic in nature. All authors pointed to the increased susceptibility to stress. It seems, then, that we are dealing with a phenomenon common to all of the animals, and that Green and Larson (1938*a*) have adequately described its pathology and physiology. Universally these die-offs follow a population peak, occur primarily in the late winter and early spring, and involve severe metabolic disturbances coincident with a markedly decreased resistance to stress.

In searching for a common cause for these changes we find that Selye's adaptation syndrome (1946, 1947) provides us with an answer to the problem. In other words we are probably dealing with the symptoms of adrenal exhaustion on a population-wide basis. Selye (1946) has already suggested that Green's shock disease in snowshoe hares resembled a disease of adaptation. The adaptation syndrome is the sum of the non-specific physiological and morphological responses to stress other than the specific adaptive reactions (such as serologic reactions to specific antigens). Selye has divided these into (1) shock, (2) counter-shock (these two combined are the "alarm reaction"), (3) resistance, and (4) exhaustion phases. Here we are probably dealing with the exhaustion phase, where the animal is no longer able to react to added stress after long, continued stresses, and the whole mechanism breaks down. Characteristic of the exhaustion phase (Selye, 1947), like those of the alarm reaction, are hypoglycemia, involution of lymphoid tissue, adrenal cortical hypertrophy, decreased liver glycogen, diminished fat content of the adipose tissue, lipid deposition in the liver, increased NPN with a negative nitrogen balance, reversal of the albumin/globulin ratio, decrease in blood chlorides, rise in blood potassium, and a marked decrease of the ascorbic acid, ketosteroid, and plasmal granule content of the adrenal cortex. Frequently during the stage of exhaustion, the adrenal cortex is found to be hemorrhagic. Often the liver only shows signs of cloudy swelling and decrease in size, but may, however, show more intensive atrophy and degenerative changes. These liver changes may be augmented by muscular exercise (Selye, 1939*b*).

In listing the changes during the exhaustion (or alarm reaction) phase of the adaptation syndrome we have practically repeated the findings in animals during the periodic die-off. Green and Larson (1938*a*) clearly showed that the

convulsions in hares did not occur until the liver glycogen dropped below 0.2 per cent, demonstrating that they were caused by a progressive fall in the glucose reserves. Experimentally they were able to stop or alleviate the convulsions temporarily by intravenous glucose injections, definitely affirming that the convulsions were hypoglycemic in nature. Epinephrine injections were ineffective. It seems more than likely that in most die-offs in mammals we are dealing with a manifestation of the adaptation syndrome with the terminal convulsions precipitated in many cases by some sudden stress, such as fear, captivity, or exertion.

The adrenal response to stress is stimulated by the secretion of adrenocorticotrophic hormone from the anterior pituitary. The mechanism by which the pituitary is stimulated is as yet unknown, but may be brought about by the release of adrenalin (Michael, 1949). As a result of demands on the pituitary of greater life-sustaining importance in response to stress, there is a shift to this function from gonad (Selye, 1939*a*) and growth (Selye, 1936) stimulating functions; so that growth slows or ceases and the gonads may become atrophic or at least diminished in functional activity. The importance of this factor will be discussed below. Also of significance is that, when the adaptation syndrome is elicited to one stress, the animal becomes more susceptible to other stresses (Selye, 1947). Fasting (Selye, 1946) and muscular exertion (Selye, 1939*b*) markedly increase the susceptibility of mammals to alarming stimuli, and may augment the changes which have already taken place. This is especially true of the hypoglycemic phase, and it is probably these factors which determine the final outcome in the form of hypoglycemic convulsions.

The adaptation syndrome may be elicited by a wide variety of alarming stimuli: environmental changes, pregnancy (Sayers and Sayers, 1949), toxic chemicals, bacterial infections (Selye, 1946), fear, rage, emotional upsets (Selye, 1946; Pincus, 1949; Michael, 1949), cold, muscular exertion, and a great many others (Selye, 1946). Assuming that the die-off is due to a manifestation of the adaptation syndrome, we must then investigate the stresses which are at work to produce this effect on a population-wide basis in mammals.

In all of the studies so far recorded, the die-off has been in the winter or early spring following a population peak the preceding autumn. Hence we have an extremely high population coming into a period of relative food scarcity, cold, and other severe climatic stresses with their attendant sequelae. Along with the attainment of high population levels, animals are progressively crowded into less and less favorable environments from an originally highly favorable nucleus (Hatt, 1930; Elton, 1942; Burt, 1949). This means less favorable foods, less good cover, and often unfavorable water supply, and other factors of submarginal living. In all probability every population peak in the wild exceeds the normal carrying capacity of the environment for that and other species, in particular during the succeeding winter. Under these conditions we would expect the following stresses: (1) food scarcity, (2) lack of proper cover, (3) increased muscular exertion resulting from longer food forage trips, (4) fights with other individuals (Calhoun, 1949), (5) increased exposure to cold from

longer forage trips and inadequate cover, (6) fighting resulting from territorial encroachment (Burt, 1940; Calhoun, 1949), (7) utilization of inadequate foods, (8) increased exposure to predators due to lack of cover as well as migration of predators into areas of abundant food supply in the form of a peak population, and (9) nutritional deficiencies. In summary nearly all emotional, nutritional, exertional, and climatic stresses are augmented and operable upon the entire population. It is of interest to note that this would impose similar stresses upon animals of all ages, agreeing well with Green and Larson's finding in hares (1938*a* and 1938*b*) in which all animals over seven weeks of age were involved. Apparently parental care ceases at about seven weeks (Aldous, 1937).

We now have a population under highly stressed conditions and undoubtedly taxing its adreno-pituitary system to the maximum. At this time (i.e., in early winter) the day length begins to increase and stimulate the pituitary in most mammals to secrete gonadotrophic hormones with resultant gonad development prior to the breeding season. That daily light stimulates the gonads via the pituitary has been shown for the snowshoe hare (Lyman, 1943), *Microtus agrestis* (Baker and Ransom, 1932), ferrets (Bissonnette, 1932, 1935; Allanson, 1932), raccoons (Bissonnette and Csech, 1937), white-footed mouse (Whitaker, 1940), mink (Hansson, 1947), and the list will probably be extended to many more. In some mammals (e.g. the ground squirrel) light has no effect upon the gonad development, but a period of low temperature is the factor which stimulates the pituitary to gonadotrophic activity (Wells and Zalesky, 1940); while in others light is the primary factor, but low temperatures may augment the reproductive activity (Whitaker, 1940). In any event in all mammals with a spring breeding season we have a factor placing increased demands on the pituitary at a time when it is already maximally stimulated to produce adrenocorticotrophic hormone in response to stress. That the gonadotrophic function is stimulated in spite of adrenal demands is evident from the fact that the breeding season with production of young does ensue. The argument might be offered that in some mammals the males are primarily affected by light, but this may be answered by pregnancy demands in the female (Sayers and Sayers, 1949; Hatfield, 1935), and growth demands in the young (Selye and Collip, 1936). We have already seen that the pituitary cannot simultaneously respond maximally to increased demands of all types, but that one type must succumb to another. If, then, the pituitary is under maximum demand as a result of the already-listed stresses, and a direct stimulus (in the form of light or low temperature) causes stimulation of gonadotrophic activity, it stands to reason that this latter must occur at the expense of the adrenotrophic activity. Hence at a time when stresses are maximal, we suddenly have an increased pituitary load, and the animals begin to succumb with symptoms of exhaustion of the adreno-pituitary mechanism, and the periodic decimation is in full swing. As one may see from the preceding discussion, all of the animals succumbing at more or less the same time is a function of the high population with its inherent stresses.

The time it takes an animal to succumb depends upon the severity and duration of the applied stress. Thus, in a population which reaches a peak in a brief

time, the accompanying stresses would be more acutely developed and their application more intense, resulting in a more sudden and pronounced population death. When a population develops more slowly, the stresses increase at a slower rate, and are applied more gradually, which would tend to attenuate the final collapse (Sayers and Sayers, 1949).

A word may be said here on the many discussions of disease as a cause of the periodic die-off. That epidemics are common during some population peaks has been shown and the subject reviewed by Elton (1931, 1942). As an example, rabies has been suggested as a population control in the arctic Canidae (Cowan, 1949). The status of rabies in the wild and its relation to population decimations has been reviewed by Gier (1948). One would expect epidemics to break out during a population peak due to decreased resistance and crowding. We have already seen that increased resistance to one stress leads to decreased resistance to others, and that resistance to all stresses is diminished during the exhaustion stage of adaptation. We can understand why infectious disease, although secondary, is not uncommon in many die-offs, and why it has been investigated as a possible primary cause. Parasities were similarly suspected, and Elton (1942) showed them not to be a cause of decimations other than as a secondary factor.

We now have a working hypothesis for the die-off terminating a cycle. Exhaustion of the adreno-pituitary system resulting from increased stresses inherent in a high population, especially in winter, plus the late winter demands of the reproductive system, due to increased light or other factors, precipitates population-wide death with the symptoms of adrenal insufficiency and hypoglycemic convulsions. The only mammal known not to have a cycle is the beaver (Clarke, 1949), and it seems likely that, throughout the recorded history of the animal, trapping pressure has been sufficient to keep the population level below the highly stressed condition. Similarly, muskrats are cyclic throughout their range except where water levels are controlled. In these areas there is usually a controlled high level of trapping pressure to keep the population from peaking to stress levels. Even these, however, become subject to crashes when extremely adverse climatic conditions lower the carrying capacity of the environment, and all the stresses of a peak population succeed with their sequelae. Such a condition probably occurred throughout the muskrat producing areas of northwestern Pennsylvania and Ohio in the fall and early winter of 1946–47. Several different pathogens were isolated from the dead muskrats at this time, primarily enteric organisms, which were in all likelihood secondary to exhaustion of the adaptive mechanism. This explanation of the die-off accounts for crashes in discontinuous large areas, as well as in different species, being out of phase, since only in one homogeneous large area will the population pressures be necessarily applied simultaneously. Species with similar habitats, size, and food requirements would be expected to be in phase, and such is usually the case (Elton, 1942).

Up to this point the adaptation syndrome has sufficed to explain the observed phenomena, but this still leaves two aspects of mammalian cycles unexplained: (1) the fixed cycle length for each general size of mammal, and (2) the differ-

ences in degree of cycling between the sub-arctic and more temperate and tropical climates. First let me say that what has been said and what will follow applies primarily to rodents, since the predators merely reflect the cycles of their food supply. For example, the foxes of Ungava closely follow the vole and lemming cycles upon which they depend for food (Elton, 1942).

Voles, mice, and similar small mammals have an approximately four year cycle (McCleod, 1933; Hamilton, 1937; Elton, 1942; Clarke, 1949). Larger mammals, such as hares, rabbits, and muskrats, have about a ten year cycle (Elton, 1942; Rowan, 1948; Clarke, 1949; Green *et al.*, 1938*a*, 1939; Chitty, 1946, 1948), while the still larger mammals have a still longer cycle (Clarke, 1949). The first fact which strikes one is the apparent relationship between cycle length and body size, but this in itself is not the answer. It seems likely that the short period of sexual immaturity, the short gestation period, and the large litter sizes of the smaller mammals are the prime factors in the short cycle. These factors lead to a lower reproductive potential in the medium-sized animals, for example, snowshoe hares require at least a year to reach sexual maturity and have a gestation period of 38 days (Aldous, 1937) as opposed to 25 days and 21 days, respectively, for the meadow vole (*Microtus*) (Hamilton, 1941). The larger animals, such as caribou, probably have an even longer cycle correlated with a gestation period of 7–8 months, and reach sexual maturity at 1½ years (Asdell, 1946). In other words, it seems highly probable that the cycle length is a function of the reproductive potential of the given animal. Those with the highest reproductive capacity build most rapidly to a population peak in excess of the carrying capacity of the environment. It is notable that the most prolific animals of their respective size groups (e.g. meadow voles and snowshoe hares) are the most prominently cyclic. Starting with a population low, we have a period of relatively heavy predator pressure on a minimal population (Elton, 1942). At this time the excess of births over the death rate will be very small, but must exist for a population increase to occur, and it is this excess with which we are primarily interested. Taking only this excess, it is understandable that this segment of the population will increase exponentially in relation to its reproductive potential. In the highly prolific *Microtus* with a short period of immaturity and short gestation period, an average litter size of 5.5 (Asdell, 1946), and capable of having up to 17 litters annually (Bailey, 1924), it can be seen that rapid increases to enormous levels are possible, and do occur. An additional factor, pointed out by Hamilton (1937), is the progressively increasing chances of immediate post-parturient mating with a resulting increased number of litters per year as the population rises and contacts between the sexes increase. A further well-known fact tending to accelerate the rate of reproduction is the increase in average litter size for about the first half-dozen litters. In an increasing population the average age is similarly increasing, which means that more maximum-sized litters are born, as well as more females reaching reproductive maturity. Since the potential reproductive capacity of any species, as well as the death rate, is relatively fixed, the cycle length will be related directly to the time it takes the population excess over the death-rate to peak to a point beyond the

carrying capacity of the environment, and hence highly stressed conditions. It can be seen that in this fashion the lower the reproductive capacity of the species, the longer will be its cycle. Environment in this discussion is used in its broadest sense, including predators, interspecific relations, and all other factors. The existence of annual cycles has not been forgotten, but, since we are speaking in terms relative to the environment, they will not affect the over-all picture. This explanation carries with it a considerable flexibility if this consideration is kept in mind, i.e. all terms in relation to the environment. Exceptionally severe or favorable environmental factors could possibly shorten or lengthen the cycle a year or so, depending upon whether operative early or late in the cycle. If extremely unfavorable conditions were brought to bear on a population at its ebb, it is conceivable that peak attainment could be delayed a year. Conversely, if this occurred when the population was high, but not at its peak, a relative peak would be caused with a resultant die-off. This same mechanism would tend to put isolated populations in phase, when not too widely separated, as in the southern mountain blocks of Norway (Hatt, 1930). These populations occur in a sufficiently small area to be subject to the same major climatic upsets, and one extremely severe upset of this kind would be sufficient to put the populations in phase for a considerable period of time. Over such a large area as Canada with its divergent climates one would not expect to find populations in phase from one extreme to the other, and such is the case (Clarke, 1949; Chitty, 1943, 1946).

One next might well ask why some population peaks assume plague proportions whereas the majority do not. On a purely theoretical basis it would seem that the maximum carrying capacity of the environment would lie much closer to the peak than any other point of the cycle. If this is so, then highly favorable conditions, particularly with respect to food, for the final season of the cycle would allow an enormously greater peak than normal. This seems to be associated usually with abrupt land-use changes which result in a greatly increased food supply, improved cover conditions, or a relative decrease in predators in relation to the sudden increase in carrying capacity of the area, or probably all of these combined. Under these circumstances, the attainment of highly stressed conditions would be delayed until both prey and predator populations have achieved a balance with the newly increased carrying capacity. The immigration of predator populations usually lags somewhat behind the development of high rodent populations with the result that for a short while the rodent peak would be limited only by the available food supply and living space.

The evidence concerning litter size during the course of a cycle is contradictory. On the basis of the proposed theory a population, as soon as it reaches a highly stressed condition, would be expected to experience a decreased fecundity with decreased litter size. When the stresses are relieved by a die-off, the birth-rate would again be expected to increase, slowly at first, and then more rapidly as predator pressure and its stresses become relatively less important. This becomes evident from the preceding discussion concerning the ability of the pituitary to secrete large quantities of gonadotrophic hormone in the face

of demands for the life-sustaining adrenocorticotrophic hormone. Fasting has been shown to result in decreased reproductive performance (Slonaker and Card, 1923*a*,*b*,*c*), probably acting primarily through the pituitary-adrenal system, as previously discussed. Aldous (1937) states that there was a gradual decline in the young per litter of snowshoe hares starting before the population decline, and continuing with it. This is understandable on the basis of the population obtaining stressed conditions prior to the actual occurrence of death. Elton (1924) describes large litters in hares during the period of increase, and smaller during the decline. Piper (1928) found no signs of breeding at the peak of an outbreak of house mice. Hamilton (1937) similarly describes a decrease in the size of *Microtus* litters during the decline. Green, Larson, and Bell (1939), however, found no significant difference in the litter sizes between the peak year and the height of the decline. Elton, Ford, Baker, and Gardner (1931) also state that the litter size in *Apodemus* decreases during the decline. That the birthrate decreases due to decreased litter size or sometimes total reproductive failure shortly preceding, during, or shortly after the population crash would be expected; but much more conclusive experimental work must be done on this point. Likewise, if Hamilton's theory (1937) of increasing chances of mating with increasing population is correct, and there is no reason to suppose that it is not, one would expect fewer litters during the early period of the cycle, and gradually increasing until the population decline.

We have, as yet, not explained why the cycles are so much more pronounced in the far north and become progressively less pronounced with decreasing latitude. This aspect of the problem is still without any experimental evidence from the field. The change from north to south is gradual; and in looking for constantly changing climatic factors which might cause this effect, temperature, day-length, and light intensity appear as three obvious factors which vary regularly and progressively with latitude. All three of these may be contributing factors if we assume, lacking conclusive evidence from the field, that the reproductive capacity in the north is greater than in the south for the same species. Whitaker (1940) has shown in a series of experiments on the white-footed mouse (*Peromyscus leucopus*) that increasing daylight stimulates the gonads to gametogenesis. However, light of low intensity caused a continuous breeding condition, regardless of day length, while more intense light caused the activity of the gonads to follow the increases and decreases in day length. He also demonstrated that low temperatures were capable of keeping an animal in a state of continuous reproductive activity with a light intensity intermediate to the above two experiments regardless of the length of day. Wells and Zalesky (1940) showed that low temperatures were necessary for continuous spermatogenesis in the male ground squirrel (*Citellus tridecemlineatus*) as opposed to the normally seasonal behavior. Low temperatures only slightly hastened the onset of spermatogenesis from an aspermatic condition in these animals. These studies provide an experimental basis from which we might postulate an increasing reproductive rate the farther north one progresses. Conversely, in areas where summer temperatures are high, there is a suppression of breeding activity in mice during July

and August (Hamilton, 1941; Howard, 1949). This is further supported by Laurie's paper (1946) on house mice in different environments. The mice living in cold stores (−21° to −10°C.) had significantly larger litters than those in warmer environments, but the number of litters was unchanged. In the same paper she reviews some of the experimental evidence for suppression of sexual activity by high temperatures (midsummer or tropical). We then have experimentally conditions which would indicate that intensive field work on one species (simultaneously carried out in a subarctic and a temperate habitat) would reveal a greater productive capacity per female per year in the far north where low temperatures, lower light intensities, and prolonged days would maintain a high level of reproductive activity. This would be opposed further south by a fall in the breeding rate during the hot summer months with a generally lower reproductive potential.

In addition to these facts, and correlated with them, it is interesting to note that the animals with the most pronounced cycles have the highest reproductive potentials in their size groups, as well as being the most daylight-active. These include meadow voles (*Microtus*), snowshoe hares (*Lepus*), lemmings, and house mice.

SUMMARY

Exhaustion of the adreno-pituitary system subsequent to the stresses inherent in a high population level, severe climatic conditions, and the demands of the spring breeding season have been proposed as the cause of cyclic declines in mammals.

The length of the cycle is probably a function of the reproductive potential of the species involved, and this potential is applicable to that portion of the population in excess of the death rate for the development of peaks. The terminating factor is the attainment of a population above the carrying capacity of the environment.

The possibility has been suggested that longer daylight, decreased light intensity, and lower temperatures during the breeding season in the north maintain a higher reproductive potential in turn leading to more pronounced cyclic changes than in more temperate climates. Field data on this matter is needed.

LITERATURE CITED

Aldous, C. M. 1937. Notes on the life history of the snowshoe hare. Jour. Mamm., 18: 46–56.

Allanson, M. 1932. The reproductive processes of certain Mammals. III. The reproductive cycle of the male ferret. Proc. Roy. Soc., B, 110: 295–312.

Asdell, S. A. 1946. Patterns of mammalian reproduction. Comstock. Ithaca. 1–437.

Bailey, V. 1924. Breeding, feeding, and other life habits of meadow mice (*Microtus*). Jour. Agric. Res., 27: 523–535.

Baker, J. R., and R. M. Ransom. 1932. Factors affecting the breeding of the field mouse (*Microtus agrestis*). I. Light. Proc. Roy. Soc. B, 110: 313–322.

Best, C. H., and N. B. Taylor. 1939. The physiological basis of medical practice. Williams and Wilkins, Baltimore. Pp. 942–943.

BISSONNETTE, T. H. 1932. Modification of mammalian sexual cycles; reactions of ferrets (*Putorius vulgaris*) of both sexes to electric light added after dark in November and December. Proc. Roy. Soc. B, 110: 322–336.

———. 1935. The avenue of reception of sexually stimulating light in ferrets. Anat. Rec., 64. Suppl., 1: 89.

BISSONNETTE, T. H., AND A. G. CSECH. 1937. Modification of mammalian sexual cycles. VII. Fertile matings of raccoons in December instead of February etc. Proc. Roy. Soc., B, 123: 246–254.

BURT, W. H. 1940. Territorial behavior and populations of some small mammals in southern Michigan. Misc. Publ. Mus. Zool. Univ. Mich., No. 45: 1–58.

———. 1943. Territoriality and home range concepts as applied to mammals. Jour. Mamm., 24: 346–352.

———. 1949. Territoriality. Jour. Mamm., 30: 25–27.

CALHOUN, J. B. 1949. A method for self-control of population growth among mammals living in the wild. Science, 109: 333–335.

CHITTY, H. 1946. The snowshoe rabbit enquiry, 1942–43. Canad. Field-Naturalist, 60: 67–70.

———. 1948. The snowshoe rabbit enquiry, 1943–46. Jour. Animal. Ecol., 17: 39–44.

CLARKE, C. H. D. 1949. Fluctuations in populations. Jour. Mamm., 30: 21–27.

COWAN, I. Mc. 1949. Rabies as a possible population control of Arctic Canidae. Jour. Mamm., 30: 396–398.

ELTON, C. 1924. Periodic fluctuations in the numbers of animals, their causes and effects. Brit. Jour. Exp. Biol., 2: 119–163.

———. 1931. The Study of epidemic diseases among wild animals. Jour. Hygiene (Cambridge), 31: 435–456.

———. 1942. Voles, mice, and lemmings. Oxford, Clarendon Press. Pp. 1–496.

ELTON, C., E. B. FORD, J. R. BAKER, AND A. D. GARDNER. 1931. Health and parasites of a wild mouse population. Proc. Zool. Soc. Lond., 2: 657–721.

FINDLAY, G. M., AND A. D. MIDDLETON. 1934. Epidemic disease among voles (*Microtus*) with special reference to *Toxoplasma*. Jour. Animal Ecol., 3: 150–160.

GIER, H. T. 1948. Rabies in the wild. Jour. Wildl. Mgt., 12: 142–152.

GREEN, R. G., AND C. L. LARSON. 1938*a*. A description of shock disease in the snowshoe hare. Amer. Jour. Hygiene, 28: 190–212.

———. 1938*b*. Shock disease and the snowshoe hare cycle. Science, 87: 298–299.

GREEN, R. G., C. L. LARSON, AND J. F. BELL. 1939. Shock disease as the cause of the periodic decimation of snowshoe hares. Amer. Jour. Hygiene, Sect. B, 30: 83–102.

HAMILTON, W. J., JR. 1937. The biology of microtine cycles. Jour. Agric. Res., 54: 779–790.

———. 1941. Reproduction of the field mouse (*Microtus pennsylvanicus*). Cornell Univ. Agric. Exp. Sta., Mem. 237.

HANSSON, A. 1947. The physiology of reproduction in mink (*Mustela vison*) with special reference to delayed implantation. Acta. Zool., 28: 1–136.

HATFIELD, D. 1935. A natural history study of *Microtus californicus*. Jour. Mamm., 16: 261–270.

HATT, R. T. 1930. The Biology of the voles of New York. Roosevelt Wildl. Bull., 5 (4): 513–623.

HOWARD, W. E. 1949. Dispersal, amount of inbreeding, and longevity in a local population of prairie deermice on the George Reserve, southern Michigan. Contrib. Lab. Vert. Biol., Univ. Mich., No. 43: 1–50.

LAURIE, E. M. O. 1946. The reproduction of the house-mouse (*Mus musculus*) living in different environments. Proc. Roy. Soc., B, 133: 248–281.

LYMAN, C. P. 1943. Control of coat color in the varying hare, *Lepus americanus* Erxleben. Bull. Mus. Comp. Zool., Harvard. Univ., 93: 393–461.

MCCLEOD, J. A. 1933. A parasitological survey of the Genus Citellus in Manitoba. Canad. Jour. Res., 9: 108–127.

MICHAEL, S. T. 1949. Adaptation to brief stress. Yale Jour. Biol. and Med., 22: 71–92.
PINCUS, G. 1949. Adrenal cortex function in stress. Ann. N. Y. Acad. Sci., 50, art. 6: 635–645.
PIPER, S. E. 1909. Mouse plagues, their control and prevention. Yearbook, U. S. Dept. Agric. 301–310.
ROWAN, W. 1948. The ten year cycle. Univ. Alta. Ext., Alta. Pp. 1–15.
SAYERS, G., AND M. A. 1949. The pituitary-adrenal system. Ann. N. Y. Acad. Sci., 50, art. 6: 522–539.
SELYE, H., AND J. B. COLLIP. 1936. Fundamental factors in the interpretation of stimuli influencing the endocrine glands. Endocrin., 20: 667–672.
SELYE, H. 1939*a*. The effect of adaptation to various damaging agents on the female sex organs in the rat. Endocrin., 25: 615–624.
———. 1939*b*. Effect of muscular exercise on the fat content of the liver. Anat. Rec., 73: 391–400.
———. 1946. The general adaptation syndrome and the diseases of adaptation. Jour. Clin. Endocrin., 6: 117–230.
———. 1947. Textbook of endocrinology. Acta. Endocrin., Montreal. Univ. Pp. 837–867 (The general adaptation syndrome and the diseases of adaptation).
SLONAKER, J. R., AND T. A. CARD. 1923*a*. Effect of restricted diet. II. On pubescence and menopause. Amer. Jour. Physiol., 64: 35–43.
———. 1923*b*. Effects of restricted diet. III. On the numbers of litters and young born. Amer. Jour. Physiol., 64: 167–180.
———. 1923*c*. Effects of restricted diet. IV. On the age of greatest productivity. Amer. Jour. Physiol., 64: 203–209.
WELLS, L. J., AND M. ZALESKY. 1940. Effects of low environmental temperature on the reproductive organs of male mammals with annual aspermia. Amer. Jour. Anat., 66: 429–448.
WHITAKER, W. L. 1940. Some effects of artificial illumination on reproduction in the white-footed mouse, *Peromyscus leucopus noveboracensis*. Jour. Exp. Zool., 83: 33–60.

Wyeth Institute, 900 Broad Street, Philadelphia 30, Penna. *Received January 9, 1950.*

THE TARSIER IN CAPTIVITY

By Charles H. Wharton

On the trip which permitted these observations, I was primarily concerned with getting a select group of little-known animals and birds to the United States. The period of observation was from December 27, 1946, to August 1, 1947. Six months of this time was spent in the province of Davao, Mindanao. The purpose of the trip precluded too wide or too radical experimentation, and the writer was forced to devote much of his time to other creatures, including peso-worshipping natives. He believes, however, that certain facts gleaned from the behavior of *Tarsius carbonarius* (Heude) during the above period might be useful, or at least interesting, to those concerned with mammals of similar habit.

A few brief notes on the natural home of the wild tarsier are in order to clarify the overall picture of the "Amus," as it is called by the Manobos.

This primitive little primate is plentiful in the province of Davao, southeastern Mindanao. The largest concentration observed was at Caburan on the Sarangani Peninsula, a singularly wild and beautiful region accessible only by boat. Here, in the space of six days, 94 live tarsiers were captured, and as many as 45 were brought in by natives in a single day. About twenty of the animals came from a second growth of small, smooth-barked trees; the remainder came from stream valleys with much the same growth. Neither locality seemed to exceed three miles from the seashore. Most of the animals were found clinging to the small trees (diameter 3 to 10 inches) or in a fork close to the ground. A typical area is one-fourth mile from the seashore at the base of a 1000-foot mountain, a large clearing bounding it on the other side; trees rarely exceeding six inches in diameter and thirty feet in height.

Out of a hundred specimens, three, one male and two females, were taken from a hollow tree. Many occupied dark tangled places. Although the tarsier sees well enough in strong light, direct sunlight may be injurious. On February 16, the noon sun killed a young tarsier in five minutes while we attempted to photograph the little one with its mother. The largest number of tarsiers found in one tree was four, at a place called Binigno, Caburan Province. Some tarsiers were found in odd places. The first one I obtained was captured on Christmas day, 1946, near Libertad, Davao Province, in a cornfield in broad daylight. It was received by my Moro agent at Madaum and placed in a special cage on December 27.

A newly born individual measures 145 mm. from tip of nose to tip of tail, with a body length of 60 mm. Measurements of a young mature male are as follows: snout to rear toe, 305 mm.; snout to tail base, 115; length of tail, 230; hind foot, 64. A large adult male will measure: total length, 400 mm.; length of body, 274; hind foot, 67. An adult female measured: total length, 364 mm.; length of body, 239; hind foot, 64. The average weight of eight female tarsiers was 3.68 ounces, while that of two males was 3.37 ounces. The majority of these animals were young adults and were weighed three to six months after being in

captivity on minimum rations. The two males were considered less than two years old. The weights of wild adults might even exceed four ounces.

The following excerpts from the writer's notes indicate cage births and mothers captured with young, and other notations of interest:

January 13.—Pregnant female and male captured in a tree together.

January 14.—Female captured with two young, one ¾ grown.

January 15.—Two females with suckling young captured. Female captured with two young, one partially grown.

January 30.—Female noted holding nearly grown female in baby position.

February 11.—Received pregnant female.

February 16.—Female bore young at Caburan.

April 3.—Female captured with two young, one aged 3 to 6 months, the other 9 to 12 months.

April 16.—Two females captured with nursing young; one young one about 3 months old, the other about three weeks.

April 16.—Two females gave birth.

April 19.—Female gave birth in cage; ate all but head of young.

June 22.—Received two females with nursing young.

June 29.—Female gave birth in cage.

Newly born tarsiers are well furred and have open eyes. The youngster may be carried across the lower abdomen or in the mouth of the parent. On April 5 the writer watched a mother tarsier carry her baby in her mouth back and forth from the top shelf to the bottom of her cage. She did this five or six times daily, often leaving it lying alone. Mothers were noted to lick the fur of older youngsters. Frequently new born tarsiers are devoured, in cage births. Sometimes, if the animals are kept on minimum rations, part of a leg or tail of a dead cagemate will be eaten during the night on which it dies.

Evidence seems to indicate that young are born the year round. In many cases the young stays with the female parent until nearly full grown, often until the next baby is well along. No evidence of twins was noted.

In the London Zoo a male tarsier showed sexual interest on many occasions, especially after the introduction of a second female on November 21. He spent much time jumping from one to the other, seizing them with both hands and generally caressing them. On no occasion did either female respond to his advances. The male kept up a persistent bird-like chirping when sexually excited. No actual mating was observed, but activities began about dusk. The male exhibited sexual interest for the last time Feb. 7, 1948.

From March on the appetite of the pregnant female became keener; she came eagerly to mealworms during the day, and moved about considerably. Originally she had been highly nervous, especially when kept alone. She became more alert, and washed the male with care and thoroughness. She remained close to him, showed him frequent attention, and the pair remained aloof from the other female where formerly they had all three huddled together.

A miscarriage occurred on April 19, a foetus about one inch long. Loss of weight due to this was 13 grams. In 15 months the greatest weight attained by this

female was 154 grams, after she had been placed with the male and the other female. The lowest weight recorded for the female was 100 grams seven months after she had been received.

Fighting frequently occurs among caged tarsiers where several adult males, in particular, are placed together. As in the case of some monkeys, male tarsiers attack females with the same degree of ferocity as they do other males. Fighting is attended by many piercing shrieks and is evidenced by severe biting of the face, ears, hands, and tail, and often ends fatally for one or more of the participants. After a brawl several tarsiers of a cageful can be seen lying on their backs on the bottom of the cage in an absolutely rigid position as if frightened stiff, legs and hands drawn up, mouth open wide, and eyes closed. The animals would remain in this position several minutes as if paralyzed. This attribute of freezing in outlandish positions of defense is one of the most fascinating of all the tarsier's peculiarities. It is accompanied, if the eyes are left open, by a vacuous staring into space, as if the tarsier were appealing to the spirits of the forest to come to its aid. After one fight a pregnant female was found dead on her back, the tail of the young protruding from her vagina.

However, the writer has had as many as eighteen individuals living peaceably together while awaiting their individual cages. Old adult males seemed to follow the primate rule by being intractable and biting the friendly hand and cagemate at the slightest opportunity. These old males are as a rule noticeably larger, with prominent scrota.

When excited, or in extreme fear, tarsiers close their eyes and savagely bite the nearest object, be it hand, lizard, or drinking container. In the National Zoo an adult female at the height of sexual attractiveness was placed in a cage with an adult male of breeding age. After watching the female intently for at least a minute the male leaped across the cage to a spot on the limb beside her. She rose up on her hind legs, grabbed the male by the shoulder, and held him at arm's length. Her other hand was thrown wide and raised, and her mouth remained open. Her eyes were staring blankly into space. The two animals remained motionless in this position for fully three minutes. Then the male very slowly and deliberately rotated his head about, opened his mouth widely and sank his teeth deeply into the female's arm, precipitating a rough and tumble fight on the floor of the cage.

The writer is no longer amazed at the wealth of folklore surrounding the tarsier. He has seen three of them sitting around a dead cagemate, holding portions of the deceased animal's anatomy. Natives claim that a male will hold a female's stomach during labor pains and will even bring her medicine. Vinencio Paler, an engineer of the Columbian Rope Company, told me of the prevalent belief that tarsiers will hold the throat of a dead companion until decomposition begins.

The tarsier's sight is excellent even under bright lights. Several instances in zoos have indicated that a tarsier's attention may be held for considerable periods of time by moving objects at least forty feet away.

Three main calls are indicated: (1) A loud piercing alarm call of a single note. The writer has heard it while walking down a trail through the habitat, during

fights, and from deserted babies, often of very small size. (2) A chirping locust-like communication where several tarsiers are within calling distance in the trees. (3) A soft, sweet, bird-like trill, heard when the animal is quiet and apparently contented. It may be heard shortly after dusk in caged animals that have been fed an hour or so before.

The odor of tarsiers is heavy and somewhat disagreeable in a confined place. It clings to trees and wood for days, and is heavy enough to enable natives to spot the general location of a tarsier in its haunts. The writer has been able to detect this odor several times in thick patches of jungle. Some tarsiers in captivity become covered, particularly about the head and hands, with a fine, reddish material which comes off on wood, hands, or cloth. This may be a secretion—certainly it carries a good deal of the odor. This gives many individuals a rufous color of the head and nape, especially in sexually mature animals.

Of the fatalities that occurred, most animals died from exposure, fighting, or lack of sufficient food. Several chronic afflictions required constant attention. Sore raw spots on feet and tail were treated and cured with applications of merthiolate and collodion. This condition was brought about by damp cage bottoms or, as it was suspected in some cases, by constant clinging to a certain vertical limb in the cage. Narrow shelves were substituted and found generally more satisfactory.

Animals developing sore eyes had been in captivity for some time and the condition is believed to indicate a diet deficiency. Matter was cleaned away daily with cotton and warm boric acid solution. Argyrol and one per cent Yellow Oxide of Mercury were both utilized. Animals in this condition were given pan-vitamins daily. The condition did not affect the animals' appetites. Although a certain amount of sunlight may be beneficial to the tarsier's eyes, the use of an ultra-violet lamp in one zoo resulted in filming-over the eyes and would probably have resulted in permanent damage had it been continued.

Cases of diarrhea were treated with one-fourth tablet Sulfasuxidine powdered and placed in the abdominal cavity of a lizard before feeding to the tarsier. Swollen, bleeding, or sloughing toes and fingers responded nicely to merthiolate and vitamin therapy. Vitamins were given by mixing a liquid pan-vitamin preparation, such as *Vipenta Roche*, in egg yolk (ten minums per yolk) and injecting this mixture into the abdomen of geckos with a hypodermic syringe. The geckos were then fed to the tarsiers.

During the care of the captive animals many precautions were taken. Daily sterilization of drinking containers was practiced. Ailing individuals were immediately isolated and their cages were disinfected with Lysol and then sun dried. As soon as one cage became dirty, the animal was moved to a clean one. The most difficult part of the entire procedure was to impress on the minds of my native assistants the importance of meticulous daily cleanliness in the feeding and caging of the tarsiers.

The ideal arrangement seemed to be one tarsier per cage, but, since quite a number of them were kept on hand, usually two were kept togteher. In one or two larger cages four individuals, usually young females, seemed to thrive together. All

cages were floored with false bottoms of wire cloth. Protection from mosquitoes was provided, and dryness was found to be absolutely essential.

Live animal food eaten by tarsiers in captivity, excluding that fed to the captive pair discussed below, included the following: Fiddler and hermit crabs among the Crustacea; large Mindanao locusts of several varieties; roaches, *Periplaneta* and *Blatta*; crickets, *Gryllus*; and cave crickets *Ceuthophilus*, among the Orthoptera. Japanese beetles, *Popillia*; rhinoceros beetles, *Oryctes*; darkling beetles, Tenebrionidae; and ground beetles of the Carabidae are eaten. Tarsiers were very fond of geckos of the genera *Hemidactylus* and *Lepidodactylus*, as well as chameleons, *Anolis*. Of *Draco*, the Philippine flying lizard, they ate only the head. A report from the London Zoo attests to the interesting fact that tarsiers will eat bee drones. In addition several larval forms of the Coleoptera were eaten, such as rhinoceros beetle larvae (*Oryctes*) and mealworm larvae (*Tenebrio*).

The intake of food is astonishing for this pair of tarsiers even though Clarke (Jour. Mamm., 24: 94–96, 1943) reports (on two captive tarsiers) that the female needed 590 calculated average calories per square meter daily, the male 680, "while Bruhn found 653 as the average of 10 rhesus and mangabey monkeys."

Some zoo keepers, losing tarsiers, have found no cause of death except general malnutrition probably brought about by not feeding quite enough, feeding only once a day, or feeding foods low in necessary food value. Clarke also found, by respiratory quotients, that tarsiers have no unexpected reserves of carbohydrate or fat that might be utilized during early stages of fasting. Even though aware of the large amount of food required by these animals, the writer was somewhat amazed to find that each of a pair of tarsiers in the St. Louis Zoo consumed 100 mealworms daily. Mealworms, usually fed from a dish on the cage floor, provide the main food for tarsiers in the zoo. Variations in diet are provided by chameleons and insects procured locally. In the New York Zoological Park they found that their pair would eat several small chameleons, two or three strips of filleted butterfish, and a few mealworms each day. The fish proved more satisfactory than the meat formerly used. Frederick A. Ulmer, Jr., of the Philadelphia Zoological Garden, disturbed by the terrific loss in the chameleon "pool," developed the unique procedure of quick-freezing these lizards and easily procurable insects to solve the tarsier food problem at his zoo.

Feeding is done from a "tripod" position, propped by the tail. If the animal is sitting on a level surface it frequently uses both hands to hold its prey. It is comical to watch tarsiers feeding on mealworms from a plastic plate about six inches in diameter. The tarsier drops into the dish, bends forward, closes its eyes, and picks up a mealworm with its teeth. It then grasps one end of the worm with a hand until the larva is started on its rapid journey through the sidewards-moving jaws.

Lizards and live insects, particularly beetles and grasshoppers, are favored food. In the Philippines several varieties of geckos provided the bulk of the live food. Each tarsier was efficiently fed by holding the lizard in a clean hemostat and moving it directly under the creatures's nose. The procurement of quantities of geckos was quite a problem. At first the writer spent many nights, with a broom

lashed to a long pole, invading houses and municipal buildings until he was convinced that he had materially lessened the lizard population of the little town of Davao. When the task became too demanding an army of small boys was recruited to bring in the lizards at five centavos each. With 30 or 40 tarsiers on hand it was necessary to spend as much as twenty-five dollars weekly on geckos alone.

Tarsiers usually kill lizards by a pounce and a bite on the head. Small lizards and geckos may be held in the teeth in almost any position without being killed first—not infrequently a lizard turns around and grabs the tarsier by an eyelid, usually resulting in a ludicrous struggle if the lizard is tenacious. The writer has seen a tarsier haul in a large lizard by the tail hand over hand much like a sailor pulling in a rope. It is no feat for a tarsier to eat from eight to twelve geckos in twelve hours.

The following excerpt from the writer's notes indicates the voracity of a captive pair: "Cage 'P' (containing two individuals) given an 8-inch green and brown skink (a common large-bodied form) at 10:00 A.M. It was chased and seized by the tail by one of the tarsiers. The other swung down and killed the lizard by biting it in the head several times. At 2:15 P.M. inspection revealed only one front leg of the lizard remaining. One of the pair has only one eye and is unusually vigorous. Since writing the last two sentences the leg has been eaten by *one eye*."

The introduction of new foods to the tarsiers was done with caution. The writer asked his two Filipino helpers to suggest new things from time to time. Once, while the writer was away for a week's trip, they fed a group dried shrimp with a resultant loss of three animals. Live locusts, which occur in tremendous swarms throughout the islands, were avidly eaten by tarsiers. They discarded the wings and spiny tibia. It was the writer's hope that dried locusts would be an acceptable food, but too few of the animals ate them, and only as a last resort.

Large (6 cm. in length) green tree frogs were common in the tarsiers' habitat; offered to captive specimens, they were attacked, but not killed or eaten. The huge grubs of the native rhinoceros beetle, *Oryctes rhinoceros*, were eaten in about one third of the cages into which they were introduced. Small fresh water crabs, fiddlers, and hermit crabs (devoid of shell) were eagerly devoured by hungry tarsiers.

At the National Zoological Park, while training the animals to take mealworms, I frequently gave them baby and adult white mice which they devoured bones, fur, and all. The tarsier, with heavy prey like these mice, may eat on the cage floor, but when possible it carries the food to a tree limb or other high spot.

Due to a heavy infestation of Japanese beetles (*Popillia*) in Washington in the fall of 1947, we had opportunity to observe tarsiers eating these small beetles. A small handful, dipped in water to prevent too rapid spreading, was placed on the floor of the cage. Tarsiers would grab them individually and eat them much as a child eats popcorn.

When disturbed while feeding another peculiar habit of the tarsier is to stop chewing and stare fixedly in some direction for as long as a minute. When more than one animal occupied a cage it was necessary to see that each got its share.

Frequently, when several lizards were turned loose in the cage, a greedy individual would eat one while holding another struggling lizard by the tail with the other hand.

Following is a record of the pair of tarsiers kept by John Hamlet and fed experimentally over a period of about two months at his home near Beltsville, Maryland. The variety and volume of food is almost staggering when we consider that a tarsier scarcely exceeds four ounces in weight.

The pair was kept in a box, dimensions 2 feet x 3½ feet x 18 inches. They were kept outdoors most of the time. Well fed, the two animals endured temperatures ranging from 51 to 89 degrees F., but suffered from colds during periods of the lower temperature. They were moved inside on cold nights.

Insects.—Southern June beetles, a large green scarabeid *Allorhina nitida* about an inch long. The pair was especially fond of these and it was comical to watch them kill the large beetles as they thumped and buzzed across the cage. Forty of these beetles have been consumed by the pair in one night. The bird-hopper, *Schistocerca americana*, the Carolina locust, *Dissosteira carolina*, and a large yellowish 'hopper (unidentified) found on the giant ragweed in Maryland, were relished. When a group of 'hoppers was introduced into the cage the tarsiers would frequently kill the whole group before eating, "gang killing," so to speak. As many as 37 large 'hoppers were devoured in one night. Fifteen preying mantis, *Stagomantis carolina*, 3 katydids, *Microcentrum rhomifolium*, over 24 cicadas, *Tibicina*, approximately 5 dragonflies, *Epiaeschna*, *Libellula*, one female dobson Fly, *Corydalis cornutus*, 6 cecropia moths, *Samia cecropia*, and 4 promethia moths, *Callosamia promethea*, were eaten. House flies, *Musca domestica*, and blue bottle flies, *Calliphora vomitoria*, were all more or less avidly eaten.

Five nests containing grubs of the paper wasps, *Polistes*, were eaten, paper and all, as is the habit of certain monkeys.

Spiders.—Of these arachnids, both wolf, *Lycosa* sp., and garden spiders, *Argiope aurantia*, were eaten.

Amphibia.—Two red salamanders, *Pseudotriton ruber ruber*, ten eastern red-backed salamanders, *Plethodon cinereus cinereus*, and one marbled salamander, *Ambystoma opacum*, were eaten. Green tree frogs, *Hyla cinerea evittata*, leopard frogs, *Rana pipiens pipiens*, and toads, *Bufo woodhousii fowleri*, were all refused.

Fish.—Dead minnows were refused. It may be well to note here that Cook (Jour. Mamm., 20: 173–78, 1939) observed several tarsiers, from approximately the same region of Mindanao, catch and eat small minnows, as well as fresh water shrimp, placed in a water container in their cage.

Reptiles.—One ground lizard, *Leiolopisma laterale*, and 5 red-headed skinks, *Eumeces laticeps*, were eaten. The largest lizard consumed by the pair was a skink of this genus about eight inches long. One animal killed it alone and it was completely devoured by the following morning. Twenty-seven common five-lined skinks, *Eumeces fasciatus*, and about 50 fence lizards, *Sceloporus undulatus hyacinthinus*, were eaten. Three adult fence lizards per tarsier, nightly, was not unusual. Ten, six-lined race runners, *Cnemidophorus sexlineatus*, were eaten.

Birds.—Some 14 live sparrows, *Passer domesticus domesticus*, were given to the

pair. The method of killing birds is particularly gruesome; there is something sinister and deadly in the tarsier's behavior that holds one entranced. Hamlet calls them "motionless ogres." When the fluttering bird is first introduced the heads of the tarsiers turn in unison following each movement. The animal closest to the sparrow then creeps stealthily forward, moving each limb independently, until within eight or nine inches of the prey. A rapid leap is followed by a fast crunching bite at the base of the skull and immediately the tarsier leaps away to watch the hapless bird flop about in its death throes. Sparrows thus bitten die in about one minute. The animal that killed the bird begins to devour it head first. Bill, skull, feet, viscera, bones, and some feathers are eaten. The wings are clipped off and left; the skin and bulk of the feathers are untouched. If one half of the bird was eaten "at a sitting," the remainder was finished several hours later.

Mammals.—One Norway rat, *Rattus norvegicus*, was given dead, and was approximately three-quarters devoured. They left one hind quarter and one front foot uneaten. They ate rib bones and front leg bones, and left femurs, and backbone uneaten. They devoured the skull and brains. Four feral house mice, *Mus musculus*, were given alive. They were killed and eaten, skin, fur, and all, leaving nothing. Some twelve white mice, *Mus musculus*, were given to this pair. As was found in the zoo, tarsiers did not like them consecutively. In eating mice there is no dissection or selective picking at the prey; whatever portion was eaten was cleanly severed from the rest. Frequently one-half or one-fourth of the mouse would be left uneaten. Two white-footed mice, *Peromyscus leucopus noveboracensis*, were eaten. One brown bat, *Myotis lucifugus*, and one short-tailed shrew, *Blarina brevicauda brevicauda*, was refused.

This pair of tarsiers apparently never shared their prey.

Dried foods.—Shrimp was eaten to a limited extent, and locusts were eaten in about one-fifth of the cages.

Cooked foods.—It is interesting to note that while tarsiers did not seem to like raw or hard boiled eggs, the pair under observation in Maryland relished small portions of scrambled eggs.

Fresh meat.—Raw meat, freshly slaughtered, was first offered to captive tarsiers on January 22 and given continuously until the latter part of August when the animals became accustomed to a mealworm diet in the National Zoological Park. The meat was cut under sterile (as near as practical) conditions into strips approximately $\frac{1}{2}$ by 3 by $\frac{1}{4}$ inches. Thirty-six tarsiers could consume about $\frac{1}{2}$ kilogram of lean beef daily. At first meat was given in the mornings when the animals were hungriest, but later it was fed in the evenings and if it was refused it was left on a shelf or branch and the tarsier ate it sometime during the night. Various ruses were adopted in order to get the animals into the habit of eating meat. Most successful of these was offering it on the end of a stick which was moved to imitate the actions of small geckos. In stubborn cases the meat strip was stuffed into a gecko's mouth and left protruding slightly. Beef liver was eaten and liked. The whiter meat of large birds was not as well liked as the darker parts.

As an experiment the writer placed ten tarsiers on a straight beef diet on March 9. The beef strips were vitamin-enriched once weekly. On March 30 the

first ill effects of the diet showed in one individual with red, swollen toes. On March 31 this animal was removed from the group and given a special diet. On April 1, two of the group died, but seven healthy tarsiers remained after 22 days of beef. The test was made to determine the effects of a straight meat diet, perhaps necessary on the last leg of a long voyage.

Foods offered, but not eaten.—From time to time certain items were offered, following the suggestions of natives and others. Corn, raisins, coconut, salmon, condensed milk, ant eggs, green vegetables, and tomatoes were not accepted. Since some animals are known to eat charcoal on occasion, and the native reports were so uniform, this substance was kept in each cage constantly. During the entire period there was no evidence whatsoever to support the claim of charcoal-eating.

Plant food.—Fruits were also offered captive tarsiers. On March 28, out of 30 animals, each offered $\frac{1}{4}$ of a banana, one animal's cage did not contain the fruit the following morning, and part of another quarter was missing from another cage. There are persistant native reports in the Davao area that *Tarsius* eats the fruit of a bush-like plant, called by the Manobo name of "Panongkit." A specimen of the fruit was sent to Dr. E. D. Merril and identified as coming from *Hornstedtia* (*Amomum*) *philippinensis* Ridl, one of a group of twenty such herbaceous plants recorded from the Philippines. These plants are about three meters high; the inflorescences and fruits are borne on very short stalks springing directly from the roots. They are aromatic like ginger and turmeric.

Unsubstantiated reports of natives also indicate that the tarsier eats in the wild a variety of fungus called, in Manobo, "Tikamag."

In conclusion the writer wishes to point out that while collecting live animals for zoological exhibition and medical studies is definitely not the way to make a life history or ecological study, it may contribute substantially to the same. Further, the writer believes that zoological parks and other groups holding captive animals can provide valuable data, especially long term observations on diet and breeding, unobservable by any other normal means.

Acknowledgments.—The writer wishes to acknowledge the valuable food experiment conducted by John Hamlet. He is grateful for the assistance of Dr. E. D. Merril, and the information and observations so kindly forwarded by Robert Snedigar, Chicago Zoological Park; Frederick A. Ulmer, Jr., Philadelphia Zoological Gardens; Lee Crandall, New York Zoological Park; M. J. Lentz, St. Louis Zoological Park; Frank McInnis, Detroit Zoological Park Commission; and Margaret Southwick and C. S. Webb of the Zoological Society of London. Many thanks go to Dr. William Mann and Ernest Walker, of the National Zoological Park, for their invaluable help and encouragement.

Department of Biology, Emory University, Georgia. *Received October 22, 1949.*

NOTES ON THE LIFE HISTORY OF THE FLYING LEMUR

By Charles H. Wharton

The writer had occasion to study the flying lemur, *Cynocephalus volans* (Linnaeus), in the provinces of Davao and Caburan, southeastern Mindanao. It was hoped, by following procedures suggested by observation of the animal in the wild and in captivity, that this strange, sole representative of the Dermoptera might survive transport to the United States and live long enough for us to substitute successfully for its normal diet.

The flying lemur, known as cabal (Manobo and Bela-an) and caguang (Visayan), is more widespread and better known than is the tarsier. Its food trees do not seem to be restricted, and its den holes may cover a wide choice of situations although it may be said, at least in the Caburan area, to prefer hollow trees on the sides of steep ravines, trees tall enough to give it sufficient altitude for an escape flight.

On February 13 the writer visited a jungle ravine near Caburan, and noted nest holes in the following types of trees: Langil, *Albizzia lebbeck* (Lin.) Bentham; lamagan, *Pygeum* sp.; nangka, *Artocarpus integra* (Thunb.) Merril; magolibas or bogo, *Korrdersiodendron pinnatum* (Blanco) Merril; and balete, *Ficus adamii* Elm. The trees examined on the above date ranged from ten inches to three feet in diameter. Out of ten den trees examined one with a base diameter of about ten inches had a hole at ground level. When shown this particular hole the writer expressed considerable doubt that a lemur would inhabit such a place, but was assured by natives living nearby that the tree had been used for a considerable period of time by a lemur. Three holes were within twelve feet of the ground. The opening in the den tree reached the greatest height in the balete and bogo trees, which are often straight trunked for a considerable distance.

Once the lemur is scared from its hideout, which is easily done by hacking on the tree, it will not return to the same hole, according to native reports, until several days later. Although easy to frighten from den trees, lemurs will die by fire or suffocation rather than leave their home. Although the males tend to be quarrelsome, a number of lemurs may utilize the same nest tree. From evidence obtained in the field the writer believes that lemurs have several alternate holes.

Cabrera (Genera Mammalium, pp. 206–07, 1925) states that the flying lemur hangs by day on the trunk or by the front legs to a branch of a tree. Thomas (Trans. Zool. Soc. London, 14: 386–87, 1898) quoting Whitehead's notes, says "the flying lemur passes the day in sleep clinging to the trunk of some large tree." The writer found no evidence of the above practice. Evidence from the province of Caburan indicates that lemurs retire at or shortly before dawn to hollow trees, where they hang head-up by their sharp claws to the inside surface.

The lemur usually leaves his retreat at dusk or on dark days shortly before light is gone. He may be observed by sitting down and quietly watching. Apparently lemurs always follow the same gliding routes from tree to tree when leaving the den tree. On February 11 I examined a hugh balete tree about 50 yards from the 'municipal building,' a simple thatched hut; provincial head-

quarters for a rather loosely governed municipality. The tree had huge supporting buttresses which radiated in all directions from the base. On climbing some of these supports I found that the tree was little more than a hollow shell some six feet in diameter. Several weeks before a large lemur measuring 31 inches in total length and the same across the spread front legs had been shot from this tree.

My Manobo companions indicated the path taken by the lemurs in leaving this particular tree, and told me that several weeks previously several natives had shot at the lemurs with bow and arrow. Indeed, an arrow was still sticking in the side of a nearby mamacoa tree. At 5:30 P.M. the writer asked a native to climb up and swing some heavy vines against the side of the forest giant. This he easily did. From a cavity opening about 45 feet above the ground a head appeared and a lemur shuttled out and around the trunk. It hesitated a moment and, with a twisting, outward leap, spread its membranes. It dropped very steeply for perhaps twelve feet, then swooped across to land on the mamacao tree, practically on top of the arrow which was impaled there. It hitched rapidly upward, keeping the tree between itself and its observers, and as soon as it had gained sufficient altitude it flew to another tree. Shooting the animal seemed to be a simple problem with the natives, once the exact landing place was determined, for experience showed that the animal would land on that spot the next time.

In no case did the writer observe a lemur 'fly' other than down a ravine or downstream. Out of some twenty trees examined he recalls only one that did not allow its inhabitant a downhill escape route.

The only lemur the writer photographed in flight gave him quite a chase. Fortunately he was able to follow the course of its leaps and climbs for several hundred yards down a dry, heavily forested ravine. Once, when galloping upward on one tree, the lemur gave a short, rasping cry as if it considered that its pursuer was too close. Again, it apparently got too high in one tree and had some difficulty in finding a footing from which to launch out into space. The sharp, curved claws of the lemur are not individually operated, but are disengaged only when the foot is thrown backwards on the wrist. If the lemur gets on a trunk, only a few inches in diameter, the matter of simultaneous release apparently becomes a problem.

Once, as an experiment, I repeatedly tossed a lemur from a tree about thirty feet high. It always chose to sail towards a group of palm trees that stood near the beach. Since the animal was obviously not in top shape and the direction it chose was down wind, it would invariably land heavily on the ground about forty feet from the tree with no obvious attempt to break its fall with the legs.

Lemurs are known to be of a low order of intelligence. When they escape the hand or cage they will leap for the nearest vertical object. The writer has seen them flop across the floor and start up a post supporting a house as if it were a tree. Among the more primitive peoples of Mindanao, lemurs are eaten for food, although their musculature is such as to provide scant nourishment. Many holes examined bore the remains of old snares set around the entrances. If the lemurs route to certain food trees lies through a coconut plantation natives may club the animals as they land near the bottom of each tree. On the island of Bohol,

most of the trees have been removed except in stream valleys, where most of the lemur population is concentrated. There the animal is sought for its fur, as well as its flesh, and the soft pelage is made into hats.

In the wild, indications are that certain food trees are regularly visited when their buds or fruits are in season. Young seed pods of the kapok, *Ceiba pentandra* Gaertn., are especially relished. Lemurs eat the fruit of the balete at certain seasons, and also the leaves of the following trees: mamacao, *Dracontomelum dao* (Blanco) Merril; indalugong, *Trema orientalis* (Linn.) Blume; bogo, *Koordersiodendron pinnatum* (Blanco) Merril; nangka, *Artocarpus integra* (Thunb.) Merril (plus young fruits); banale, (scientific name unknown) a plant used as a light source by the Manobos.

In captivity, lemurs were at first kept in three-foot-square cages, but these were soon discarded for a large communal, wire-covered cage eight feet long and six feet high. Six or eight of the animals often occupied this larger enclosure. They squabbled vocally when hanging in a group and lemurs were seen to nip at each other with their teeth. Only one instance of serious intent was observed, when a male chased another male down the tree provided in the cage.

Lemurs have a rasping cry which, at close quarters, is hard on the ears, and which may be heard quite a distance. The sound is about as loud on the intake of breath as it is on expulsion. When first grasped and held the lemur cries almost without a break until released. While jostled by another in the nest box lemurs were heard to give a nasal whine of annoyance, followed by a series of rapid, intermittent bleats in the same rasping tone, but lowering on the scale.

Lemurs hung at rest in various positions on the limbs placed in the cage, and from the wire. The usual position was suspended, sloth-like, with the four feet grouped together. An occasional lemur will hang from its hind legs only. A nest box was eventually provided; the bottom and one side opened with slats so arranged that the front and rear feet could get a purchase on the inside of the box. About four lemurs could crowd into this box side by side, always in a characteristic position, emerging each evening to feed. Even newly caught lemurs feed readily. One can place them on a branch held in the hand and have them begin to feed oblivious of several onlookers maneuvering around them with cameras. Captive lemurs can be stroked without much offense to the animals. A sweet agreeable odor surrounds them. They are clean. When wet or dirty they can not rest until they have groomed themselves thoroughly. To void solid excrement, which is a goat-like pill, or to urinate, they hang by the front legs from a branch, drop the hind legs and curl the tail up over the back. A pocket-like space just exterior to the anus is opened by this action.

The greatest enemy of the lemur in captivity seemed to be wetness on the inside of the flight membranes, causing the loose skin to become irritated with accompanying raw spots and restlessness. This condition was either brought about or aggravated by the constant hanging upside down, with no chance to dry the membranes by gliding and normal feeding activities. The flight membrane is so thin that one can almost read through it, and it is thinly furred, yet it is a source of great difficulty to the caged animal. The nest box, by allowing the lemurs to

hang as they do normally during the day, helped the situation immensely. The use of towels and various powders where the leg joints had rubbed raw areas helped, but in no instance did a wet lemur live long. Mothers were sometimes brought in with young. The little fellows invariably became wet inside and died within 24 hours after caging. Such females would frequently leave the youngsters hanging by themselves to dry out for several hours.

While walking in the branches and feeding the flying lemur always remains upside down. A long, string-like muscle about 2 mm. in diameter connects the shoulder to the edge of the web and draws the membrane down under the fore legs so it will not be caught on branches. However, lemurs with small holes in the patagium are occasionally taken.

A lemur which has a head and body length of about 16½ inches, has an intestinal tract 11 feet long. The stomach is ten inches long with a three inch caecum; the first portion of the intestine is 6 feet 9 inches long passing into a 19-inch caecum, followed by a three-foot colon. The entire make-up of the animal is adjusted to a vegetable diet of considerable bulk.

The dentition is very peculiar. In some specimens the shark-like premolars project visibly. When the animal does bite in defense it really holds on, although the principal thing to watch is their needle-sharp claws. The lips are muscular and calf-like. One is struck by the similarity of a lemur's head to that of a young ruminant.

In feeding, the lemur uses the front foot to pull leaves within reach of the mouth. He then shears off leaves or portions of the fruit, or pulls the leaf off and chews it in like a rabbit, head down and stationary.

During some four months when the lemurs were under observation, they were offered a wide variety of vegetables and fruits. They ate portions of green pepper, cooked green corn (on the cob), green corn shucks, and avocado, but none of these in any appreciable amount. Their main diet consisted of bananas, in many cases they preferred the skins, okra, and young kapok pods. From time to time they were given leaves and fruit of the jackfruit, *Artocarpus integra*, bogo, *Koordersiodendron pinnatum*, and leaves of cassava, *Manihot utilissima* Pohl. Flowers, young leaves, and buds were the most desired parts.

Out of the approximately forty-one lemurs received, twenty-two died from respiratory complications. Most of them succumbed between the third and fourth weeks of captivity. Dampness of the underside coupled with an inadequate food supply were probably the most important factors. The lemur requires a relatively large amount of leafy material. It is in the process of conditioning the animals to a more easily procurable food supply that most losses occur. To combat the frequent pneumonia-like condition often accompanied by coughing and running at the nose, penicillin was administered to certain individuals every four hours. One lemur was cured of his symptoms by this method. Dissection revealed heavy infestations of intestinal flukes, small roundworms, and tape worms in many specimens.

Lemurs more or less constantly licked their wet membranes on the inside. Mothers attempted to lick youngsters dry by licking both inside and outside

of the young one's membranes. Once a male was observed to lick the wet underlayer of a motherless young lemur.

Lemurs probably drink in the wild by licking wet leaves. Water cups attached to the wire cage sides were utilized by the animals with much snuffling and head-shaking, for, in attempting to lick the surface of the water, their noses invariably went under. Glass tube drinking devices were installed and were much more satisfactory.

Babies must sometimes be left hanging alone while the mother is feeding. They remain quiet until the mother returns. To let them out, the female drops the front leg following the same procedure as when the youngster must defecate, and the young one reaches up and grasps the limb. To help the little one get back into his living cradle, the mother lemur comes alongside and drops a front leg. The baby always seems to hang across the abdomen, rear feet on one side, fore feet on the other, needle-sharp claws dug into bare and apparently insensitive patches of skin where the flight membranes join the female's sides. In several cases lemurs were captured with young ones in place, almost $\frac{1}{3}$ as large as the mother. No female lemurs were received with young smaller than with a head and body length of eight inches. Lemurs with young from eight to ten inches long were received March 3, April 10, April 30, May 18, and May 21. One young per animal is indicated.

Young lemurs nurse from two nipples in the axilla of each fore arm. The young lemur normally lies across the mother so that its head is near the nursing area. On April 21 a three-fourths-grown lemur was observed to nurse while hanging on a limb alongside the mother. The foreleg of the female was down, giving him ready access to the glands.

Lemurs were easily sexed by color. Males are dark, chocolate brown and may be heavier of build, especially around the head and neck, while females are gray. Out of the forty-one lemurs received, two females were a beautiful reddish-tan, a rare phase. Subsequent examination, of the Smithsonian's series of East Indian lemurs, by Dr. David H. Johnson and the writer, indicated that the sex-color relationship held true for skins from a wide area of Indonesia.

The writer expresses appreciation to Dr. E. D. Merril, who checked the plant nomenclature, and Dr. David H. Johnson of the U. S. National Museum for his assistance.

Department of Biology, Emory University, Georgia. *Received October 22, 1949.*

PARTURITION IN CERTAIN INDIAN BATS

By P. A. Ramakrishna, M.Sc.

Fascinating is the study of the birth of young in bats. But our knowledge in this line is meagre. The few descriptions of bat parturition (Belon, 1555; Kuhl, 1817; Jobert, 1872; Blake, 1885; Rollinat and Trouessart, 1896; Whitaker, 1905; Sherman, 1930 and 1937; Mohr, 1933; and Wimsatt, 1945) were limited till very recently to the British, Continental, and American species of Microchiroptera. Nothing is known about the Megachiroptera from any part of the world or about any Indian species of either suborder. Lack of material and the difficulty of observation may be responsible for these lacunae in our knowledge of this subject. Since the pioneer observations of Rollinat and Trouessart (1896) it has been assumed that breech presentation is the normal mode of birth in bats, the only exception to this being Daniell's (1834) description of head presentation in *Nyctalus noctula*.

In a preliminary communication (Ramakrishna, 1948), some observations on the occurrence of the head presentation were described for the first time in two species of Indian bats: the Indian Short-nosed fruit bat, *Cynopterus sphinx sphinx* (Vahl), and Schneider's Horse-shoe bat, *Hipposideros speoris* (Schn), representing the two different suborders of Chiroptera. This method of birth to young supports the unique century old observations of Daniell on *Nyctalus noctula*.

Observations on the parturition in Hipposideros speoris.—In the early hours of the morning of April 17, 1948, a few bats (*Hipposideros speoris*) were removed from a colony at Tumkur. The females were pregnant and some were near term. During transport to the laboratory one of them had given birth. The young one, born with eyes closed, weighed 2.1 grams. It was found attached to the nipple of the mother with about 6 mm. of the cord attached to the umbilicus. The mother was hanging in her normal position head downwards, licking the young bat all over and resting at intervals. The infant died about thirty minutes after its arrival in the laboratory.

On the same afternoon, by 1:00 P.M., one of the females showed repeated signs of restlessness by constantly shifting her position in the cage. In order that her behavior might be watched, she was isolated, and by about 1:13 P.M. she had settled down to one spot in the cage. She hung head downwards, by her posterior extremities, in the normal resting position, but with her legs stretched far apart. The vulvar opening showed signs of appreciable dilatation and was experiencing muscular paroxysms. By 1:25 P.M. the paroxysms became fairly rapid and violent and the bat was seen to bend occasionally acutely forwards and then straighten herself as if in much pain. At 1:37 P.M., following three very violent contractions, a third of the fetus covered by the fetal envelopes was excluded from the vagina. The mother bent forwards, tore off, with her teeth, the exposed part of the fetal envelopes, and began to lick briskly the amniotic fluid which was flowing out as a result of the rupture. The fetus emerged head first. The first part to be exposed was the crown, and in close contact with the side of the head was the left bent

pinna. The vigorous licking of the young by the mother followed, and by 1:42 P.M. the strong muscular paroxysms helped to release the young up to the neck. It appears as if the caudo-cranial direction in which the mother licks the young forms an additional help to release it. The birth was completed at about 1:51 P.M., and once free the young bat was carefully nursed and licked all over. The young one, born with its ventral surface facing the abdomen of the mother, crawled in search of a teat and succeeded in getting one. During all this time the umbilical cord, about 16 mm. long, was still connected with the placenta within the vagina. This condition persisted till about 6:30 P.M. when I left the laboratory. At birth the eyes of the fetus were closed and the body was flesh coloured. The tips of the ears stand out only after two days.

When I returned at 7:00 P.M. the umbilical cord had been cut about 5 mm. from the umbilicus. The oozing of small quantities of blood from the vaginal orifice had stopped and it appeared clean and normal. Three drops of blood on the floor of the cage led to the suspicion that the placenta might have been pulled out and eaten by the mother. She was sacrificed and an examination revealed that this had indeed occurred between 6:30 and 7:00 P.M. The stomach was filled with freshly eaten afterbirth. At 3:15 P.M. the next day, the cord had detached from the umbilicus and the young died later in the evening, evidently due to hunger since the mother had been sacrificed the previous evening.

Observations on the parturition in Cynopterus sphinx sphinx.—Nine females of *Cynopterus sphinx sphinx*, collected at Hoskote, March 14, 1948, were brought to the laboratory on the following afternoon. Five of the females had given birth and were in lactation with the young attached to the nipples. Of the remaining four adults, one died on the way to the laboratory and the embryo, recovered from the uterus, weighed 9.8 grams. Another female had given birth to a dead young which weighed 10.1 grams. A third was found on its back, obviously tired from overcrowding in the basket, and was in the act of parturition. A third of the fetus, covered by the fetal envelopes, had emerged from the vagina. The muscular paroxyms ceased with the death of the female. The fetus was delivered by means of a forceps; it weighed 10.8 grams.

At 1:08 P.M. the ninth female was seen shifting her position restlessly and repeatedly in the wire cage. Slow muscular paroxysms started in waves by 1:14 P.M., while she was hanging in her normal resting position with her legs stretched apart. During labor she was seen to bend forwards acutely at intervals as if in much pain. These continued for some time and by 3:01 P.M. considerable dilatation of the vagina was visible; by 3:13 P.M. nearly a half of the fetus, wrapped in the fetal envelopes, was projecting from the vagina. The female tore the membranes with her teeth. The head of the fetus was turned to the right; the left wrist was exposed by 3:22 P.M. (Pl. I, no. 1). The constant licking by the mother helped the young one to be completely released by 3:26 P.M. At this stage the young one dropped suddenly, the cord snapping at the umbilicus, and began to bleed. It was gasping for breath and died a few seconds later. Its eyes were open, and it had a dark coat of hair on the forehead and back with sparse distribution on the outer parts of the body. The tips of the ears were closely

applied to the sides of the head (Pl. I, no. 3). From the fact that the five suckling young, brought to the laboratory when a few days old, had the ears partially or completely bent over the head, it appears that they stand out in 6–10 days (Pl. I, no. 2). The new born weighed 11.2 grams.

The placenta was inside the genital tract, with the umbilical cord projecting out until 7:00 P.M. The mother was showing signs of exhaustion, due to lack of food and rough handling during transport, and died a little later. Attempts made to revive her proved fruitless.

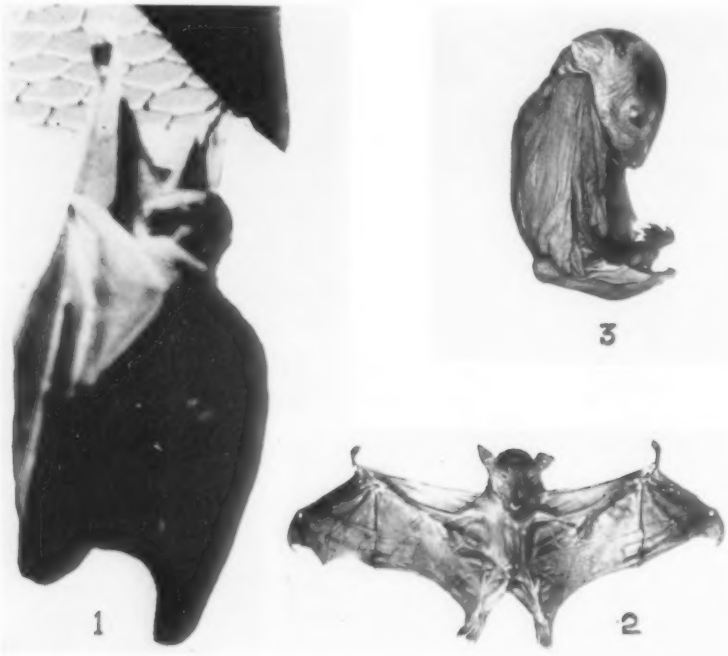

PLATE I

Cynopterus sphinx sphinx: 1, head presentation, ⅔ natural size; 2, young a week old, with spread out wings, showing the upright condition of the ears, ½ natural size; 3, newborn young with open eyes and folded pinna, natural size.

A detailed record was maintained of the frequency of labor contractions from the time the mother began to experience muscular paroxysms to the time of completion of parturition. The interval is two hours and eighteen minutes, though the actual time taken for the birth of the young is only about 25 minutes.

There was a series of muscular paroxysms, including two violent ones, separated from each other by short intervals ranging from 5–13 seconds. Each series was separated from the next by 5–8 minutes. The young was completely expelled during four series of contractions.

Discussion.—The foregoing accounts of the birth of the young in *Hipposideros speoris* and *Cynopterus sphinx sphinx* agree in some aspects with the accounts extant on parturition in bats. The normal posture assumed by the mother during parturition was to suspend herself by the claws of the hind and forelimbs, like the spider. Blake's (1885) observation on the phyllostomid bat (*Erophylla planifrons?*) differs in that the female rarely hangs by both hind limbs. The usual position is stated to be by one foot only, with the other bent at right angles. In *Hipposideros speoris* and *Cynopterus sphinx sphinx* the female hangs only by the extremities of the hind limbs from the cross wires of the cage with the legs stretched far apart, agreeing in the latter aspect with the condition described for *Nyctalus noctula* by Daniell (1834).

The open condition of the eyes during birth, in *Cynopterus sphinx sphinx*, does not seem strange, since Jones (1945) recorded this feature in *Artibeus planirostris trinitatis*, where the young bat was found to have its eyes open two hours after birth. He also refers to Sherman's unpublished observation on *Tadarida cynocephala*, one of the Molossidae. It appears that the eyes of the fetus were open while in the uterus in the former.

In the Vespertilionidae, generally, the young one is received in the cloak formed by the alar and prominent interfemoral membranes of the mother. *Cynopterus sphinx sphinx* does not develop any such device to receive the young, nor does *Tadarida cynocephala* (Sherman, 1937). Bélon's (1555) observation that the mother does not receive the young in a receptacle is interesting. Taken in the light of Allen's remark that the species may be one of the Horse-shoe bats, *Hipposideros speoris* provides another instance where such a cloak is not formed for the reception of the young, in spite of there being a well-developed interfemoral membrane. The young squirms on the abdomen of the mother and easily attaches itself.

The teeth of the mother play an important part. They are used to sever the umbilical cord and also to free the fetus from the fetal coverings during emergence from the vagina. The exact manner in which this is done is not clear in the examples cited by Kuhl (1817) and by Rollinat and Trouessart (1896). It is interesting that the tearing of the fetal envelopes is done with the claws of the hind feet in a phyllostomid (Blake, 1885) and in *Tadarida cynocephala* (Sherman, 1937). When the fetal envelops are ruptured the amniotic fluid flows out and is usually licked up by the mother. The frequent licking of the young by the mother during birth also aids its release while engaged in the vagina.

The eating of the afterbirth by the mother appears to be a normal feature. The failure of the mother to devour the placenta appears to be normal with *Myotis l. lucifugus* (Mohr, 1933, and Wimsatt, 1945) and *Tadarida cynocephala* (Sherman, 1937). The fate of the placenta is unknown in Kuhl's (1817) example, also in the case of *Cynopterus sphinx sphinx*. It may be concluded that the placenta is eaten in the case of *Hipposideros speoris*. Bélon (1555) suggests that the eating of the afterbirth serves to nourish the mother during the interval after parturition and until the young one is capable of taking care of itself while the mother hunts.

Studies on bat parturition in the Vespertilionidae, Molossidae, and Phyllostomidae have resulted in the general acceptance of the breech presentation as the normal mode of birth in bats. Information is lacking in the forms studied by Bélon and Kuhl. Until recently, Daniell's (1834) observation of a head presentation in *Nyctalus noctula* was considered unique among bats, since it was the only instance on record. From the observations presented in the two Indian species, the head presentation appears to be more general than imagined.

LITERATURE CITED

Allen, G. M. 1940. Bats. Harvard Univ. Press.

Bélon, Pierre. 1555. L'Histoire de la nature des oyseaux, avec levrs descriptions, & naifs portraicts retirez dv naturel: escrite en sept livres. 4to, Paris (28), 381, (1) pp. illus. (Quoted from Allen.)

Blake, H. A. 1885. Note on the parturition of a West Indian bat. Sci. Proc. Roy. Dublin. Soc. 4: 449.

Daniell, G. 1834. Observations on the habits of the pipistrelle, Vespertilio pipistrellus, and the noctule, Vespertilio noctula in captivity. Proc. Zool. Soc. Lond. 2: 129.

Jobert, C. 1872. Études d'anatomie comparée sur les organes du toucher chez divers mammifères, oiseaux, poissons et insectes. Ann. Sci. Nat., ser. 5, Zool. 16: 112.

Jones, T. S. 1945. Unusual state of birth of a bat. Nature. London. 156: 365.

Kuhl, H. 1817. Die deutschen Fledermause. (Quoted from Allen)

Mohr, C. E. 1933. Observations on the young of cave-dwelling bats. Jour. Mamm. 14: 49.

Ramakrishna, P. A. 1948. Head presentation in Indian Chiroptera. Nature. London. 163: 176.

Rollinat R., and E. Trouessart. 1896. Sur la reproduction des chauve-souris. Mém. Soc. Zool. de France, 9: 214.

Sherman, H. B. 1930. Birth of the young of Myotis austroriparius. Jour. Mamm. 11: 495.

———. 1937. Breeding habits of the free-tailed bat. Jour. Mamm. 18: 176.

Whitaker, A. 1905. Notes on the breeding habits of bats. Naturalist, London, pp. 325.

Wimsatt, W. A. 1945. Notes on the breeding behavior, pregnancy and parturition in some vespertilionid bats of the eastern United States. Jour. Mamm. 26: 23.

Department of Zoology, Central College, Bangalore. *Received June 8, 1949.*

NOTES ON THE FLORIDA PANTHER, *FELIS CONCOLOR CORYI* BANGS

By Ross Allen

In the past there has been much controversy as to the panther's ability to scream. In this connection the following observations seem noteworthy. In 1938 I built a round corral, 75 feet in diameter, for the purpose of making motion pictures of Florida animals. In this corral a female Florida panther from time to time would voice a series of screams. She always stopped when anyone approached, however, and although her cries were frequently heard, she was seldom caught in the act of vocalizing. I took to hiding in the bushes, down

PLATE I

Female panther from Collier County, Florida

wind, in the hope of seeing the panther scream. Eventually my patience was rewarded. The panther stood with her neck held straight out, and with her mouth pointed toward the ground. She then opened her mouth to about half its possible gape and voiced a series of loud, grating shrieks. The scream of this panther could be likened to a high, rasping human voice loudly shrieking "Ouch!," the sound being prolonged for about three or four seconds, and repeated from three to seven times in succession.

I have had a number of Florida panthers in captivity. These were kept in cages rather than in a corral, and were never heard to scream. They did, however, make a number of other sounds, particularly during the spring of the year, which is the mating season. Female panthers in oestrus, caged next to a male, were noted to utter many pathetic sounds—various crying and "meowing" noises, up and down the scale. After mating, these calls ceased.

Florida panthers were successfully bred in captivity at my animal exhibit. It was observed that a number of matings were made over a period of several days. On one occasion a single male kitten was born 98 days after the last mating. Florida panther kittens, like the young of other subspecies of *Felis concolor*, are spotted; I have seen specimens about one-third grown that still retained the juvenile markings.

During the filming of motion pictures in the afore-mentioned corral, I saw a large male panther, of about 160 pounds weight, kill a female deer weighing about 95 pounds. The panther stalked the deer, kept close to the ground, and occasionally twitched his tail nervously. When he was within 15 feet, he sprang at the doe, which instantly leaped away. The panther overtook the deer, leaped on its back, seized the animal's neck in his jaws, and put one foot over the deer's shoulder. The two went down in a struggling heap. The deer fought valiantly, several times kicking the panther so effectively as to tear off patches of fur. The panther continued to chew on the deer's neck, finally killing his prey after several minutes. The panther walked off a short distance and licked his wounds. Then he returned and, seizing the deer by the neck, dragged it under some bushes and began covering it up. He scraped up leaves and debris with his feet, and then smoothed it over with his nose. After this task he lay down in the shade. During the night he ate part of the deer.

A few observations were made on wild panthers in Collier and Glades counties, in the Florida Everglades. Here I caught two panthers alive, and accidentally killed another while attempting to capture it. In this area panthers several times followed or stalked me; such actions have been recorded for other subspecies of *F. concolor* in the western United States. On one occasion I discovered two young panthers on an island in the Everglades, and tried unsuccessfully to force them into the water, where they would have been more readily caught. Apparently *F. c. coryi*, like other subspecies of panthers, has an aversion to water, although swimming well when forced to it.

The Florida panther seems to be "rangier" in build than western panthers, and also seems to differ slightly in facial expression. These characteristics are shown in the accompanying photograph (Pl. I) of a female specimen from Collier County, Florida (photograph by Mr. Tod Swalm).

The Reptile Institute, Silver Springs, Florida. Received October 14, 1949.

BEHAVIOR OF THE MOLE (*SCALOPUS*) AND THE SHREW (*BLARINA*)

By John J. Christian

In the many published studies on moles there has been very little said of the behavior of captive individuals over a period of time. During the spring of 1949 I had the opportunity to observe a *Scalopus* for almost a month. During this time I was impressed by many distinctive behavior patterns as well as many points of similarity to those of *Blarina*. In the following account I have included detailed day by day accounts of both the *Scalopus* and a *Blarina*, the objects of these observations. In general the behavior patterns of the two were very similar except that the mole reacted more slowly as will be seen in the following accounts.

On May 1, 1949, after a light afternoon shower, two young moles (*Scalopus aquaticus*) were spaded, unharmed, from surface runs in a cemetery, Montgomery County, Pennsylvania. One was a 31-gram female and the other a 54-gram male. Both moles were placed in an aquarium 8 x 14 inches square and ten inches high in which a layer of soil, ⅔ sand and ⅓ clay loam, 2 to 3 inches deep had been placed, and then placed in a damp cool (65° F) cellar where there was very little daily variation in temperature or humidity. Although occasionally used, worms could not be obtained in sufficient numbers, so white mice which were readily available formed the bulk of the diet. The smaller mole did not survive the first night, but the other lived for almost four weeks, and this formed the basis for the following account.

The *Blarina* was trapped, apparently unharmed, on August 9, 1946, during the course of work on the Pennsylvania Mammal Survey in Butler County, Pennsylvania. It was put in an aquarium cage and kept under periodic observation until it escaped on August 20, 1946. Some of the notes on its behavior are included in the *Blarina* account below.

DETAILED *SCALOPUS* ACCOUNT

May 1, 1949.—Both moles were placed in the cage. The 54-gram mole made itself immediately at home, burrowing into the loose soil with a breast-stroke type of motion of its forepaws with no rotation of its body from side to side. The younger 31-gram mole had a great deal of difficulty digging, even in this loose soil, but finally succeeded in covering itself. This mole would not eat a proffered worm, but when held in the hand it readily ate squirrel brain from a pair of forceps, as well as taking milk from a dropper. When this mole smelled the brain or milk held close to its nose, it opened its mouth, somewhat in the fashion of a young bird, as though it had been used to being fed. About three dozen large and small worms, which immediately dug into the dirt, were placed in the aquarium.

May 2.—The larger mole was still alive and well, but the younger was dead. At 6:00 P.M. a 20-gram, freshly killed white mouse was placed in the cage. It had not been touched by 10:00 P.M.

May 3.—The mouse placed in the cage the previous evening was nearly completely devoured, only one foot and a few tufts of hair remained at 7:00 A.M. At 4:30 P.M. the mole was above the surface, in one corner, apparently trying to escape, but retreated below the surface as soon as I approached and turned on the light. A 25-gram, freshly killed mouse

was dropped in what seemed to be the mole's exit run. Within the next 15 minutes the mouse was dragged beneath the surface. About 50 worms were also placed in the cage at this time. Four hours later several of the worms could still be seen, but no activity on the mole's part was observed at this time.

May 4.—Only the tail and a piece of fur remained of the mouse put in yesterday. Another 30-gram mouse was placed in the cage alive, but the mole could not catch it, and finally left it completely alone. The mouse remained well, but frightened. The mouse was then killed by cord sever and thrown in the cage diagonally across from the mole. The mole immediately came underground to that corner, where its nose protruded above the ground an inch or so from the mouse, wiggled around, and again disappeared below the surface to emerge again alongside the mouse. The mouse was then investigated, with much activity on the part of the nose. Finally the mouse was grabbed by the abdomen and pulled partially into the run, where the mole proceeded to rotate the mouse end over end, without revealing himself until he had the top of the head and back directed down. At this point the facial region of the mouse was investigated by the mole's nose, grabbed, and the mouse pulled into the burrow. This, of necessity, must have been accomplished by backing up, although I have seen this mole reverse its direction very rapidly in a tunnel by turning completely around without any enlargement of the hole. This was accomplished by a sidewise doubling without rotation of the body. I suspect that most of this animal's reversal of direction in a tunnel is of this latter type rather than by backing up.

I did not watch the live mouse in the cage the entire time; but an hour after placing it there the mole was not molesting it. However, the mouse was attacked immediately after being killed and replaced in the cage. Was the mole able to realize in some way that the mouse was dead, or did he think a new food source had been thrown in? There was no hesitation or delay, and action followed immediately upon replacing the dead mouse; in fact the mole was dragging it under the earth before reflex kicking had ceased.

A beetle and a few of the worms still remain from last night. I would judge from this, and the way the mouse was attacked, that the freshly dead mouse offered a more pleasing dish than did the regular diet. This well could be true and would not show up in stomach analyses, since in the wild state a mole would rarely have a chance to feed on a mouse. I am certain that they are incapable of catching a living, healthy, adult mouse, although nestling young would in all probability be eaten if encountered. In this inability to catch mice, the mole closely resembles the *Blarina* (Cf. below), except for the fact that it is slower.

May 5.—Mouse remains weighing 21.6 grams were removed: skins, tails, and odds and ends. These remains were all thrown up around an opening in the center of the cage which led to the mole's tunnel system. These and all subsequent remains removed were washed free of dirt and the excess water thoroughly squeezed out before weighing. A 25-gram mouse was put in at 4:45 P.M., which occasioned much running around underground on the part of the mole, but the mouse was left untouched. Two hours later the mouse had been pulled below and there were runs opening to the surface where the mouse had been.

May 6.—At 4:45 P.M. the mole was above ground trying to climb up the corner of the aquarium. Mouse skin and scraps of feet weighing 7.5 grams were removed and a 25-gram mouse was stunned and placed in the cage. The mole must have detected the mouse, either by vibration or scent, as it immediately tunnelled over, with its nose periodically coming above ground, apparently to locate the mouse. The tail was reached and examined, and, without biting it, the mole retunnelled and came up by the body. It bit the body and the mouse moved away. Again the mole tunnelled and came up under the tail, sniffed it without biting, and retunnelled to the body again. The mouse again moved away. This was repeated a third time, this time with the mole succeeding in grabbing the flank and pulling the mouse underground. Twice more the mouse escaped and the whole process was repeated, but finally it succeeded in holding the mouse with a flank bite. At first the mouse attempted to struggle, working its feet in the mole's face to no avail, as well as trying to bite the mole as it bit into its flank. At this point the mouse was pulled underground, but the mole was only

partially covered and much working of the hind feet could be seen. After 15 seconds of this, the animals were uncovered and the mouse was dead with no reflex kicking. The thoracic and abdominal cavities were open with the mole feeding on the intestine. Apparently the mouse was held against the side of the tunnel by the mole's forepaws, and then bitten on the chest and abdomen while being held. All of this, from the time of the flank bite to the uncovering, took less than one minute—an incredibly short time. Pearson (Jour. Mamm., 23:159, 1942) reports having found no poisonous substance in *Scalopus* salivary glands, but it is inconceivable to me that the mole could have killed the mouse so rapidly by any other means, especially since there were no head wounds. The matter is being reinvestigated at present. That the mole did not constantly grip the mouse in its teeth was certain, as the mole's nose and head were seen free. A paralytic death seems to be the only logical conclusion.

Two hours later the skin, thighs, tail, and hind feet of this mouse, weighing 8.7 grams, were found discarded on the surface. These mice are skinned out by the mole just as efficiently as the mammalogist finds his specimens skinned by *Blarina*.

I am convinced that the mole could not catch an unstunned mouse. The mole did come out on the surface after this one, and moved quite rapidly, but I think its ability to locate the mouse only by feeling with its nose would preclude any healthy capture, and it is further limited by the mouse's much greater speed. Its ability, however, to locate the general site of a mouse from underground, across the length of the aquarium, seems rather remarkable. Apparently scent plays some part in this process, as indicated by the periodic protruding of the nose above ground, wiggling it around, and then retunnelling towards the mouse.

At this time the mole appeared healthy, normally voracious, and extremely active, but it apparently did not partake of the water placed in a heavy ash tray, as it was continually found filled with dirt.

May 7.—A 25-gram, heat-prostrated, and quite inactive mouse was put in the cage. The mole was already out and apparently hungry, as it immediately attacked the mouse and tried to pull it underground. It was prevented from this by my holding the mouse by the tail; so the mole went right ahead and ate. This time the head was eaten first with the skin held between the forefeet, toes pointing laterally; and in this way the skin was gradually stripped back as the body was eaten. The mole ate from 5:00 to 6:00 P.M., consuming about half of the mouse and leaving the rest. It was so anxious to eat that uncovering, motions, noise, and light did not seem to disturb it.

May 8.—Fifty worms fed to mole, but it was not observed eating any.

May 9.—A dead mouse (23 grams) was placed in the cage at 4:30 P.M. The mole immediately came underground from the opposite corner of the cage, poked up through, made one grab, and pulled the mouse into the tunnel at an amazingly rapid rate.

May 10.—At 6:00 A.M. the mole was out and active. A 25-gram mouse was immediately seized and dragged under. At 4:30 P.M. another 30-gram, living, but slightly stunned, mouse was given to the mole. The mouse's equilibratory sense was partially knocked out, but it was very capable of motion and fighting. The mole immediately came over and grabbed it by the tail. The mouse fought back, attempting to bite, apparently unsuccessfully. After a short struggle of this sort, the mole made a skin-breaking bite in the scrotal region, but not through the abdominal wall, and the mouse died almost simultaneously with the bite. This whole performance was fully witnessed, and the mouse was very active and struggling until that one bite, which was followed by no motion whatsoever. This again strongly suggests a salivary poison of some sort (Neurotoxic?).

May 11.—A 29-gram live mouse was given the mole, which was on the surface. The mouse was caught several times, but fought back vehemently. The mole did not succeed in making a deep bite, although the mouse was caught and held several times. I finally killed the mouse to prevent injury to the mole. The mole did not appear injured, but it did seem very tired. Its lack of sight was apparently its greatest handicap, since it would get close enough to the mouse, but could not see where to grab it. Washed remains weighing 18.7 grams were removed.

May 12.—At 6:30 A.M. a 25-gram mouse was put in. At 10:00 P.M. a 29-gram mouse was put in. Remains removed weighed 29.2 grams.

May 13.—The cage was completely cleaned and the dirt replaced with clay-loam soil. Mouse remains (13 grams) were recovered, but no worms or grubs were found.

At 7:00 P.M. a 30-gram freshly-killed mouse was placed in a large empty wooden box with the mole. The mole immediately went after the mouse, first biting the head, causing a flow of blood, then starting to feed at the anus. From here it worked forward inside of the skin. The skin was held apart at the opening by the forefeet, palms outward, as one might hold a burlap sack, and then it ate forward in this fashion with the skin working back and off as it went. The process is just like holding a paper bag open, and eating the contents, once the initial opening is made. This leaves a cleanly skinned-out mouse. Although some feeding around the lips took place, eating from the anal end forward seems to be the usual process. The mole had not progressed very far in its meal when I placed it and the mouse back in the regular cage with fresh dirt. It immediately burrowed in, then just as promptly came out and started feeding again. A short while later it pulled the mouse partially under the soil, continuing to eat from underground. The mole continually spills the water by burrowing under the dish as fast as I fill it, but it seems to be healthy without water. Are they able to survive without any water other than that resulting from metabolism or their food?

At 11:00 P.M. the mole was asleep in a hollowed pocket of earth. It assumed the same position as *Blarina* (cf. below)—upright with its head curled under and between the forefeet. Its nose was directed posteriorly so that the top of its head rested on the ground. The forefeet were likewise directed backward with the palmar surface up.

May 14.—At 7:00 A.M. the mole was asleep in the same position as described above. Two respiration counts were made: 40 and 42 per minute. Respiration movements were deep and were largely abdominal. The mole was fed a 25-gram mouse in the afternoon.

May 15.—Mouse remains (8.5 grams) were removed and a 43-gram eviscerated starling (*Sturnus vulgaris*) body put in. The respiration rate was again counted, 50 per minute, and the mole was again asleep in the above described position. The animal sleeps very profoundly; it was rolled over on its side, still in the same position, before it woke up and burrowed into the dirt.

May 16.—At 6:00 P.M. a 24-gram mouse was fed the mole, which was again sleeping soundly with a respiration rate of 41 per minute. Dropping lettuce on its back did not awaken or disturb the animal. When it did arouse, it was ravenously hungry, as usual, and immediately tore into the mouse. As soon as satiated, it again fell into a profound sleep in the same position. This eating and sleeping pattern is quite similar to that of *Blarina*. The same peculiar quality of breathing was noted—the whole body moving with the respiratory movement.

At 7:30 P.M. the mole weighed 46 grams. There is apparently a weight loss since capture, but the animal appears well and healthy.

May 17.—A 25-gram mouse was placed in the cage at 6:30 A.M. and another, 23 grams, at 5:00 P.M. At the latter time, the first mouse was entirely eaten except for the skin. Mouse and starling remains (16 grams) were removed, and four worms added.

May 18.—The mole weighed 51 grams one-half hour after eating (very little of a fresh 21-gram mouse). It drank a little water from the dish.

May 19.—The mole acted hungry at 6:30 A.M., and a 33-gram mouse was added. It also drank when water was placed in the dish. At 5:30 P.M. the mouse was almost completely uneaten, but four hours later it was completely gone except for the skin and part of the head. In every case the bones have been eaten completely excepting those in the uneaten entire parts. Remains (16 grams) were removed at this time. A fresh 24-gram mouse was immediately dragged beneath into a tunnel, and succeeding activities were not observed.

The preceding night a dropper water-bottle was put in instead of the dish. At 5:30 P.M. there was a mound of dirt under this with the spout opening plugged with mud. This was cleaned and rearranged, only to be found plugged again four hours later.

May 20.—A good part of the second mouse from yesterday still remained in the morning, but was completely gone by 4:30 P.M., and the mole was out with its usual hunger activity. This hunger excitement was accompanied by squealing with a high pitched squeaking noise. A 41-gram mouse was put in the cage.

May 21.—Water-extracted ground beef (10.5 grams) was fed the mole, and 25 grams of remains removed. At 6:00 P.M. a 28-gram mouse was put in. By 7:00 P.M. the mouse, as well as the hamburg, was almost completely eaten.

May 22.—At 9:00 A.M. a 32-gram mouse was added and was immediately attacked and eaten. At 10:30 A.M. a 19.5 gram English sparrow (*Passer domesticus*) was added.

May 23.—Ground beef weighing 46 grams was put in at 6:30 A.M., and a 25.5-gram mouse at 5:30 P.M. Leftovers that were removed weighed 23.5 grams.

May 24.—A 20-gram mouse was put in at 6:00 A.M., and a 24-gram mouse at 5:30 P.M.

May 25.—At 6:00 A.M. the mole was sound asleep, and did not awaken when a 28-gram mouse was added. At 5:30 P.M., 44.3 grams of remains were removed and another mouse, 25.5 grams, was fed as described in the following account.

The mouse was placed with the mole in a wooden box with no dirt. The mole went for the nape of the neck first, very rapidly succeeding in making an opening in the skin. With powerful digging-type thrusts of the forefeet, the toes caught in the skin edges of the opening, the hole was ripped wide open and the skin simultaneously stripped back from anterior to posterior. The skin about the ears acted as an anchor and lever base. This peeled the skin in one stroke from both front legs and shoulders. With the opening held wide with the forefeet, the nose was then pushed into the sack-like cavity in an exploratory fashion. A hole was immediately bitten through the ventral thoracic cage, and was then promptly ripped open with the forefeet, almost severing the forward from the after part of the mouse. The lungs, heart, and liver were immediately eaten. This part of the body was then abandoned and the head attacked, which was by that time completely severed. Some throat structures were eaten, then penetration of the skull was achieved and the brain eaten. Any bone was chewed and eaten along with the softer tissues. After finishing 5 grams of the mouse, the mole moved off and went to sleep in the usual characteristic position. During the whole procedure the mole seemed somewhat handicapped by its inability to brace its hind feet on the smooth wood surface, which it continually tried to do.

In attacking this mouse the primary entry into the chest cavity appeared very purposeful, the entire body having been explored with its rapidly wiggling nose before the apparent right spot was located and an initial bite made. When driven away, it came back and again had to search for the spot at which it had been feeding, by-passing other parts of the mouse. It apparently distinguishes between living and dead animals, as most attacks on living mice I have seen were first directed at the anal region or nearby abdomen, while on dead animals a more leisurely site-selection is apparent. The differentiation must be made on the basis of the lack or presence of motion in the mouse, as little temperature loss would have occurred in any of the dead mice between killing and immediate placement in the cage. These facts, combined with the distance from which it would come after a live mouse, strongly support the idea that its food detection is by vibratory rather than olfactory sense. Tactile and vibratory discrimination appear to be most highly developed.

Two hours after eating five grams, the mole weighed 50 grams, an obviously variable factor depending upon when weighed in relation to eating. In general, the mole appears healthy and very active. The temperature in the cellar remains constant at about 65° F. and the humidity very high: close to saturation at all times. This no doubt helps to maintain the animal, since it makes unnecessary water-conserving deep burrowing. As far as I have been able to tell, the water consumption of this mole has been minimal, in spite of the fact that some was always available.

May 26.—The mole was found dead in a feeding position. It apparently died while eating a 20-gram mouse which had been put in the cage early in the morning. There was a sudden severe drop in temperature during the night, causing the cellar to become very cold, which may have been the cause of death, since the mole could not burrow deep enough for warmth.

The animal's dead weight was 46.5 grams. Autopsy showed 3.5 x 2 mm. abdominal testes with no sperm in the testes or epididymis. A large (0.5 cm.), encapsulated, purulent abscess was formed between the skin and superficial muscles over the sacral region, probably a result of picking the animal up by the skin in that region. No fat deposits were evident, but all organs appeared normal in size and color. The cold, abscess, and somewhat insufficient diet all probably contributed to death, with the cold being the precipitating factor.

The total food put in, excluding the mouse of May 26, adds up to 937 grams in 25 days, while 219 grams of remains were removed. This is 28.72 grams per day net consumption, or between 50 and 55 per cent of its total weight daily.

DETAILED *BLARINA* ACCOUNT

August 9, 1946.—A 25-gram, dead *Microtus* was put in with the *Blarina*, as soon as the latter was placed in the cage at 11:00 A.M. The shrew started eating almost immediately, starting in the facial region where black ants had eaten the skin away. It stopped eating at 11:15 and resumed at 11:25. It towed the mouse under a piece of cotton which had previously been put in the cage; so the cotton was removed. It then drank some water and began resting; but at 11:30 it was again eating, very rapidly chopping through the jaw bone. Its movements were made with great speed and all the while its nose was wiggling, much like a highly animated worm and very similar to the mole's nose motion. At 11:40 the animal stopped eating and began to sleep, in a position identical to that described above for the mole, with its head tucked under its abdomen. The *Blarina's* eyesight is evidently very poor, as it seems to find meat and water entirely with its nose, and apparently can't detect a mouse in any way when more than one cm. or so away. The function of the nose in this respect appears to be as much tactile as olfactory. Later on the animal was again so soundly asleep in the same position that upon touching it it merely fell over on its side in the same position, without awakening. This is again notably similar to the mole's sleep. The respiration rate, while resting, was counted at 140 per minute, or about three times as rapid as the mole's. The shrew, however, is a whirlwind of energy while awake, a state apparently induced by hunger, as its main function seems to be eating. The diametrically opposite activity levels of its sleep and wakening times is conspicuous, both being done to what strikes one as being an immoderate degree. This same characteristic is true of the mole and constitutes one of the outstanding aspects of its behavior. Food consumed during the first 24 hours weighed 20.5 grams.

August 10—At 10:00 A.M. a live juvenile *Peromyscus*, with an injured and useless hind leg, was put in the cage with the *Blarina*. Seven minutes elapsed before the shrew had immobilized the mouse. The mouse fought back vigorously, and at first the shrew had a hard time finding it after each escape, again succeeding apparently by very close-range smell. Many biting passes made at the mouse were successfully avoided before the *Peromyscus* was finally caught. After the mouse fought back, the shrew became very wary of it. Most attacks were made at the throat and right side of the face with one or two at the scrotal region. The shrew began eating around the right facial region before the mouse was dead. The front leg motion while attacking and eating was notable; both front legs were out perpendicular to the side and rapidly flapped up and down, similar to a bird's wing flapping. This apparently serves to increase leverage and make its weight more effective.

August 15—The *Blarina* cage was cleaned this afternoon, which caused great excitement. Its box-home was removed with the result that the shrew became very active and attempted to escape, climbing all over the cage and screening in an effort to find an exit. Every small opening was rapidly investigated with its nose. A new box was placed in the cage and a mouse body wired to the screening to prevent the shrew from dragging it into the box, as it had regularly done before. The shrew tried to move the mouse, and failing in this, it moved the box to the mouse and succeeded in getting the mouse in it. The shrew is able to climb around the wood and wire cage very agilely, and would come from the top of the cage (10½ in.) by hanging by its hind feet and then dropping. It was able to run upside down around the ¼-inch hardware cloth top very easily. It seemed to climb up in a corner more easily than on a flat side, but had no difficulty with either.

DISCUSSION AND SUMMARY

In the foregoing detailed accounts, most points of particular interest have been fully discussed and need no further elaboration at this point. Below I have summarized what I consider to be the most important items.

Digging.—In the digging operations observed, which would probably be the shallow tunnel type, no body rotation was observed at any time. The digging strokes of the forefeet were entirely antero-posterior thrusts, either alternate or simultaneous.

Sleeping.—The sleeping position of the shrew and mole were identical with the head curled under the body and the forefeet directed backwards. Both animals fell into a profound sleep as contrasted to enormous activity when awake.

Activity.—The resting respiratory rate of the mole was about one-third that of the shrew and their activities were roughly proportional when compared with each other. The mole consumed about half its weight daily, the shrew better than its own weight; the actual food consumed being about equal for the two animals.

Attack.—Both animals attacked the anal and facial regions, the mole more the former and the shrew the latter. The site of attack varied, with the mole it depended upon whether the prey was alive or dead.

Location of prey.—Both animals depended to a high degree on very close-range tactile and olfactory senses to examine prey before biting. It has been suggested that distance perception by the mole was by vibratory sense. The highly mobile and active nose seems to be the principle organ used in this capacity in both animals. Possibly the mole's ears serve for vibratory discrimination at a distance. The eyes seem to be of no use whatsoever to either animal. It is highly improbable that the mole could successfully attack an adult mouse in the wild, due to the limitations of its prey location and slower mobility.

The possibility that a salivary gland poison may aid the mole in immobilizing or killing its prey has been suggested.

The method of stripping the skin from the body of a mouse by a mole has been described, and it is not unlikely that the thoroughly skinned out specimens found in traps were perpetrated in much the same fashion by wild *Blarinas* or other shrews.

An example of what appears to be an act of intelligence has been described, in which a *Blarina*, unable to pull a mouse into a box, moved the box to the mouse. The desire to eat under cover suggests that *Blarinas* probably drag their prey into runs to eat whenever possible.

In the above points, there are many notable similarities between the behavior of *Blarina* and *Scalopus*. These are specific examples, but the general impression of similarity is much greater than can be adequately described. Their behavioral likenesses are certainly more pronounced than their differences, which indicates a closer relationship than one would be led to suspect from the dissimilarities in gross structure and the highly specialized adaptations of the mole.

Wyeth Institute, 900 Broad Street, Philadelphia 30, Penna. *Received November 16, 1949.*

SOME VARIATIONS IN THE SUPERFICIAL MUSCLES OF THE BACK OF THE ALBINO RAT (*RATTUS NORVEGICUS*)

By P. V. Hoyer and R. M. Lane

Three male albino rats of the same litter were dissected and their musculature studied. Because the conditions of some of the superficial back muscles were found to differ considerably from those described by Greene (Amer. Phil. Soc. Trans., n.s., 27: 1–370, 1935) and to approximate more closely the conditions found by Orcutt (Jour. Mamm., 21: 37–52, 1940) in the pocket gopher (*Geomys bursarius*), they seemed worth recording. On removal of the *panniculus carnosus*, variations were found in the *acromiotrapezius*, *spinotrapezius*, and *latissimus dorsi* as follows.

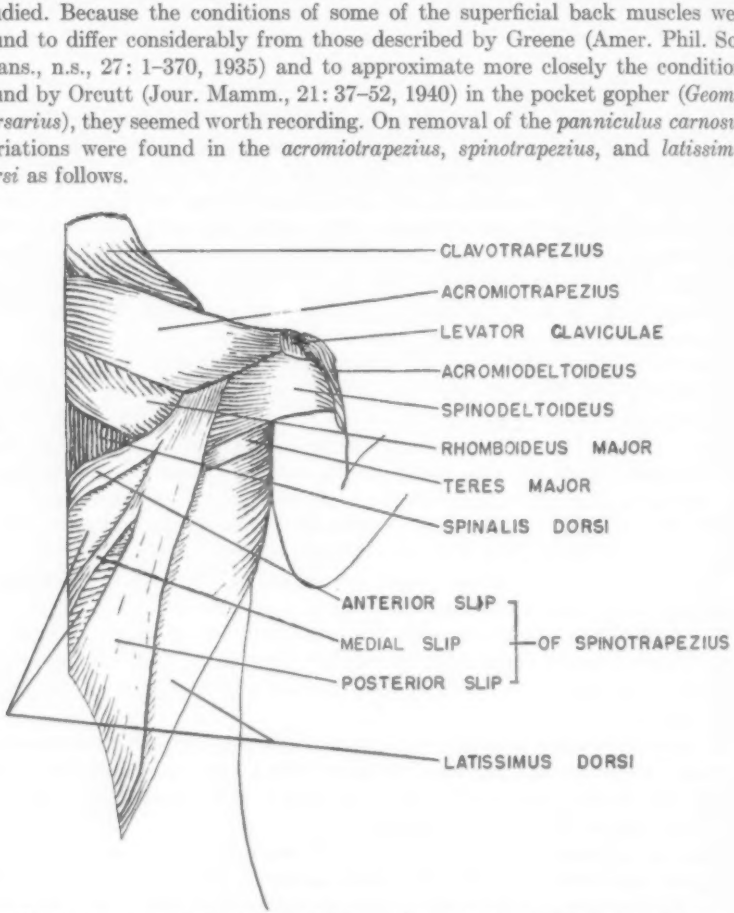

Fig. 1.—An anomaly in the superficial muscles of the back of *Rattus norvegicus*.

M. acromiotrapezius is a thin triangular muscle arising from the spines of the first five cervical vertebrae. It runs and converges laterally and slightly posteriorly to insert into the acromion process and the spine of the scapula. This condition differed greatly from that established by Greene where the origin extended

caudally to the spine of the fourth thoracic vertebra. The insertions were the same in all cases.

M. spinotrapezius was found to be a thin muscle which originates at the mid-dorsal line from the spines of the vertebrae, and the fascia form them by three separate slips which run anteriorly and laterally to converge before they insert as a single muscle into the proximal third of the spine of the scapula. These are referred to as the anterior, medial, and posterior slips of the *spinotrapezius*. The posterior slip is the most extensive of the three and takes its origin from the spines of the eleventh and twelfth thoracic vertebrae and the fascia arising from the spines of the vertebrae back through the third lumbar. The medial slip was the thinnest of the three and closely associated with the posterior slip. In one specimen the medial slip came from the spine of the eighth thoracic and was less closely associated with the posterior slip; in another it came from the spine of the ninth thoracic and was very closely associated with the posterior slip; and it was not found in the third. The anterior slip was very distinct from the other two and had its origin from the spines of the fifth and sixth thoracics. Greene (*op. cit.*) described the *spinotrapezius* in the rat as a full muscle sheet having an origin from the vertebral spines of the fourth thoracic through the third lumbar. Orcutt found the *spinotrapezius* in the pocket gopher to have two sections of origin; the anterior arising from the spines of the fifth and sixth thoracics and the posterior arising from the spine of the twelfth and the fascia from the spines back through the third lumbar. Again the insertions were found to be the same in all forms.

M. latissimus dorsi arises from the spines of the vertebrae and the fascia extending from them, from the sixth thoracic through the third lumbar. Its fibers converge laterally and anteriorly towards the axilla and insert by means of a tendon into the upper third of the medial surface of the deltoid ridge of the humerus. This condition is identical with that found in the pocket gopher by Orcutt (*loc. cit.*), while Greene's rat has its origin extending from the eighth thoracic through the third lumbar.

It is of interest to note this variation of musculature within the same species yet consistent within the same litter, suggesting a genetic control. Also of interest is the fact that we found such similarities between the rat and pocket gopher, pointing up the complicated interrelationships found throughout the order.

Biology Department, Amherst College, Amherst, Mass. *Received December 30, 1949.*

FAUNAL NEST STUDY OF THE WOODRAT, *NEOTOMA FUSCIPES MONOCHROURA* RHOADS

By Roland D. Walters and Vincent D. Roth

Nest surveys of mammals are becoming increasingly important. The life histories of internal parasites are often connected with one or more associated animals, and many new species are often found in such nests. A survey was conducted on the sleeping nest (or inner nest) of the dusky-footed woodrat from June 13 to June 27, 1949. Nest samples were taken from all the habitats in which the woodrat was found in the vicinity of Corvallis, Oregon. The area covered was fifteen miles both south and north of Corvallis and ten miles both east and west of this city.

Thirty nest samples were used, and these were taken from fifteen different habitats. The inner nest was carefully taken from the nest proper and placed in a paper sack. The animals were then removed from the debris by putting the nesting material in a Berlese funnel.

The inner nest of the woodrat was composed of finely shredded bark and twigs, grass, hair, leaves, and usually some food remnants, The food plants of this species in the Corvallis area were listed by English (1923). Usually a small amount of scat was amongst the nesting material.

The woodrat in this area is usually associated with the fringe zone of Douglas fir (*Pseudotsuga taxifolia*) and white oak (*Quercus Garryana*). Interspersed among these dominant trees is a heavy growth of shrubby vegetation which serves as food and protection. Occasionally the streamside habitat with a characteristic growth of red alder (*Alnus rubra*), big leaf maple (*Acer macrophyllum*), and willow (*Salix* sp.) is utilized.

Some forms of the associated invertebrate fauna that were obtained from the woodrat nests were probably of incidental occurrence. Others were connected with some plant used in the nest construction. The relationship of many of the forms to the woodrat will require further study. Vestal (1938) mentions a few invertebrates from the woodrat's house in the Berkeley, California, area, none of which are in our list. The following list of animals has been determined as far as present knowledge on west coast forms will allow. Many genera need revision, and in many cases the larval forms are unknown so some of the specimens were only determined to genus. A few of the species are new as indicated. In some instances present knowledge only warrants determination to family.

It may be of some value to give the relative abundance of the forms and some ideas of the continuity or discontinuity throughout the area studied. Mites were very abundant with an estimated 250 specimens per nest. Fleas, pseudoscorpions, cryptohpagids, staphylinids, and ants were found commonly in all the nests, but occasionally one of the nests would harbor 10 to 15 times as many of one or the other as normally found. The remaining groups were found in numbers of one to ten; some were continuous and others discontinuous throughout the area.

The following authorities have willingly aided the authors in the determinations, and to them we extend our sincerest thanks,. W. H. Anderson, F. W. Baker, H. W. Capps, J. C. Chamberlin, R. V. Chamberlin, S. E. Crumb, C. J. Goodnight, A. B. Gurney, M. H. Hatch, C. A. Hubbard, G. M. Kohls, H. P. Lanchester, H. B. Mills, C. F. W. Muesebeck, A. Peterson, C. W. Sabrosky, R. I. Sailor, M. R. Smith, A. Stone, E. C. Van Dyke, and E. H. Weld.

LIST OF SPECIES

DIPLOPODA: 2 sp. to be det.
CHILOPODA: 2 sp. to be det.
CRUSTACEA (Isopoda):
Armadillidiidae; *Armadillidum vulgare* Latr. ?, im.
Porcellionidae; *Procellio scaber* Latr. ?, im.
ARACHNIDA:
Phalangida; Phalangidae, imm.
Pseudoscorpionida; Chernetidae, *Dinocheirus sicarius* Chamberlin MS.
Acarina;
Liacaridae, *Liacarus* sp.
Laelaptidae, *Euhaemogamasus ambulans* (Thorell).
Tydeidae, *Tydeus* sp.
Carabodidae, *Cepheus* sp.
Oribatellidae, *Oribatella* sp.
Eremaeidae, *Eremaeus* sp.
Oribatulidae, *Scheloribates* sp.
Belbidae, *Belba* sp.
Galumnidae, *Galumna* sp.
Glycyphagidae, *Glycyphagus* sp.
Parasitidae, *Pergamasus* sp.
Ixodidae, *Ixodes angustus* Neumann, *Ixodes spinipalpis* Hadwen & Nuttall, *Ixodes rugosus* Bishopp.
Araneida;
Oonopidae, *Orchestina*.
Erigonidae, 2 sp. to be det.
Agelenidae, *Calymmaria* sp., im.
Lycosidae, 1 sp. to be det.
INSECTA:
Thysanura; Machilidae.
Collembola;
Entomobryidae, *Entomobrya tampicensis* Mills, *Entomobrya* sp., *Tomocerus* sp., nr. *vulgaris* Tlb., *Tomocerus*, imm.
Neuroptera; Raphidiidae, larvae.
Corrodentia; Trogiidae, *Liposcelis* sp., nr. *niger* (Banks).
Hemiptera;
Anthocoridae, *Lyctocoris* sp., nymph.
Nabidae, *Nabis* sp., nymph.
Lygaeidae, Subfamily Rhyparochrominae, Genus and sp.? All nymphs.
Aradidae, *Mezira* sp. (possibly an undescribed sp.), adult.
Coleoptera;
Leptodiridae, *Nemadus pusio* LeC.
Staphylinidae, *Arthrolips decolor* (LeC), *Micropeplus laticollis* Makl., *Medon convergens* Csy., *Xantholinus* sp., larvae, *Hesperolinus parcus* LeC., *Quedius erythrogaster* Mann., *Atheta* (Metaxya), nr. *satanas* Bernh., *Baryodma verna* Say, Close to Omaliinae, one larvae. Ptilidae, Genus and species??

Histeridae, *Gnathoncus* sp., *Dendrophilus xavieri* Marseul.
Elateridae, *Limonius infuscatus* Mots, larvae.
Cryptophagidae, *Coenoscelis ferruginea* Sahlb.?
Lathridiidae, *Coninomus nodifer* Westw., *Cartodere argus* Reit.
Lepidoptera; Phalenidae.
Oecophoridae, *Hofmannophila pseudospretella* (Stainton), larvae.
Diptera;
Itonididae, Genus and sp.?
Fungivoridae, *Bradysia* sp.
Scatopsidae, *Scatopse* sp., larvae.
Scenopinidae, prob. *Scenopinus* sp., larvae.
Chloropidae?, larvae.
Sphaeroceridae, *Leptocera* sp.
Muscidae, *Fannia flavibasis* Stein, *Fannia* sp., larvae.
Siphonaptera;
Dolichopsyllidae, *Orchopeas sexdentatus cascadensis* Jordan, 253 spc., *Diamanus montanus* (Baker), 2 spc., *Monopsyllus wagneri ophidius* (Jordan), 2 spc.
Hystrichopsyllidae, *Catallagia charlotennsis* (Baker), 3 spc., *Leptopsyllas segnis* (Schonherr), 1 spc.
Hymenoptera;
Cynipidae, *Aulacidea* n. sp.
Ceraphronidae, *Ceraphron* sp.
Formicidae, *Tapinoma sessile* (Say)., *Stenamma* sp., *Aphaenogaster subterranea occidentalis* Emery, *Leptothorax nevadensis rudis* Wheeler, *Lasius niger* L. var., near *sitkaensis* Perg.

LITERATURE CITED

ENGLISH, P. F. 1923. The dusky-footed wood rat (*Neotoma fuscipes*). Jour. Mamm. 4: 1–9.

DONAT, FAE. 1933. Notes on the life history and behavior of *Neotoma fuscipes*. Jour. Mamm. 14: 19–26.

VESTAL, E. H. 1938. Biotic relations of the wood rat (*Neotoma fuscipes*) in the Berkeley Hills. Jour. Mamm. 19: 1–36.

Museum of Natural History, and Entomology Department, Oregon State College, Corvallis, Oregon. *Received September 4, 1949.*

FIELD AND LABORATORY OBSERVATIONS ON ROOF RATS, *RATTUS RATTUS* (LINNAEUS), IN FLORIDA

By C. Brooke Worth

Extensive information on the life history of Norway rats, *Rattus norvegicus* Berkenhout, is on hand, particularly as the result of publications by workers of the Rodent Ecology Project at the Johns Hopkins School of Hygiene and Public Health (Davis, Emlen, and Stokes, 1948; Davis and Emlen, 1948; Emlen and Davis, 1948; Emlen, Stokes, and Winsor, 1948). The biology of this animal is well known not only from field studies, but also from laboratory observations on various domesticated strains (Donaldson, 1924; Griffith and Farris, 1942). Considerably less information exists on the roof rat, *Rattus rattus* (Linnaeus). The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Division of The Rockefeller Foundation in co-operation with the Florida State Board of Health.

During the course of investigations on murine typhus fever in Hillsborough County, Florida, during 1948 and 1949, it was possible to trap and handle large numbers of roof rats. It is the purpose of this paper to summarize the experiences thus gained, and, when possible, to compare findings with those reported for Norway rats.

Almost all the rats were obtained with box traps similar, except for being smaller, to the one described by Richter and Emlen (1945). Metal "Hav-a-hart" traps were used in addition in some rural environments. Bait consisted of commercial horse feed containing cracked corn, oats, and chopped alfalfa leaf impregnated with molasses; a slice of carrot, sweet potato, or apple was usually added.

Trapping in urban areas, chiefly Tampa, Florida, was conducted on a block-to-block basis, while rural trapping was centered on farms. Hillsborough County has five chief types of farms, namely, beef cattle, dairy cattle, poultry, citrus, and truck, all of which may be rat-infested.

Traps were visited daily except over the week end. The animals were able to survive 48 hours or more in unattended traps, provided they were not exposed to direct sunlight. At the laboratory the rats were anesthetized, bled for complement-fixation test for typhus, combed for ectoparasites, dusted with DDT to complete disinfestation, marked for identification by a combination of toe clippings, and then placed in cages for subsequent observation and experiment.

Subspecies.—Three subspecies of *Rattus rattus* were found to occur in Hillsborough County: *R. r. rattus*, the black rat; *R. r. alexandrinus*, the alexandrine rat; and *R. r. frugivorus*, the fruit rat. Of these, alexandrine rats are prevailing. Occasionally the fruit rat will be found to the exclusion of the others in a citrus grove, while the black rat may invade a barn or a warehouse without subspecific companions. It is likely that most of the populations are genetically mixed, for the three forms readily interbred in our laboratory, the litters exhibiting traits of

both parents. Furthermore, it is often difficult to assign a wild-caught rat to a given subspecies owing to its transitional appearance. For this reason we refer to the group at the specific level, *Rattus rattus*, or roof rat: the observations to be recorded do not pertain to individual subspecies unless so stated.

Distribution.—Continuous trapping in Hillsborough County during the two-year period revealed an almost uniform distribution of roof rats in and about centers of human activity. They were absent or rare where the Norway rat was to be found. Norway rats, however, were restricted chiefly to certain parts of cities; it is unusual to find them on farms. Within the cities the Norway rats occupied wharves, warehouses, parks, dumps, embankments, and slum areas for the most part, while roof rats were found in some warehouses and especially in the middle- and upper-class residential districts. The roof rat outnumbered Norway rats about five to one in the county; this ratio is greater when only rural areas are considered—2768 roof rats and 498 Norway rats were caught.

While the Norway rats of Tampa live characteristically in burrows, the roof rat less often inhabits excavations. The most prevalent habitats of the roof rat are outbuildings filled with trash or stored materials, attics of dwellings, and the crowns of palmetto trees planted close to houses. Elevated retreats are reached by climbing any sort of shrubbery, pipes, or wires on the sides of these structures; many attics must be invaded by walking along horizontal wires from the nearest telephone pole and thence clambering through ventilating louvers. "Grease" marks where these wires reach the wall of the house are a common sign of rat infestation.

The frequent practice of maintaining poultry in the back yards of urban residences, in addition to the cultivation of a variety of fruit trees, contributes to the welfare and wide distribution of roof rats in Tampa. Large oak trees, draped with Spanish moss, afford additional elevated harborage in some parts of the city. Garbage, finally, is often disposed of carelessly in back alleys.

On farms roof rats are found in greatest abundance in the various outbuildings where they occupy hay mows and any material which may have been stored on overhead rafters. However, they are encountered frequently also in fields, along fencerows, or at the edges of swamps, sometimes several miles from a house or barn. The fact that females accompanied by young litters have been taken in box traps in such locations indicates that they can lead feral lives quite apart from the benefits conferred by human activities. Roof rats were trapped in Everglades National Park at an abandoned sawmill seven miles from any occupied structure.

The fruit rat, especially, is inclined to lead an outdoor existence. On citrus farms its characteristic attacks on oranges and grapefruits are a familiar sight throughout entire groves. Ripe fruit is selected, and both the seeds and pulp are consumed. Plate I shows some typically eaten oranges. Opossums and raccoons mutilate the fruit rather than gnaw it symmetrically. Chickens foraging on fallen fruits produce a ragged edge on the rind. It is, therefore, possible to determine the presence of roof rats in a citrus grove merely by walking through it; moreover one can make an approximation of the number of rats present.

These feral rats must live in competition with native wild rodents, particularly the highly abundant cotton rat, *Sigmodon hispidus* Say and Ord. We have several times taken roof rats and cotton rats simultaneously in a box trap. The animals had not fought, although they occupied opposite ends of the trap. Feral roof rats cannot be regarded as refugees from areas occupied by the dominant Norway rat, since the latter species is rare in the country. It must be either that pressure within its own populations causes some roof rats to stray away from farm

PLATE I

Oranges eaten by roof rats

buildings, or that conditions in Hillsborough County are favorable for the resumption of feral behavior by a commensal species. The facts suggest that the roof rat has not advanced as far as the Norway rat in anchoring itself to dependence on mankind.

Ectoparasites.—Restriction of the Norway rat to a more limited habitat results in its harboring fewer species of ectoparasites than the roof rat. During the two-year period nineteen species were recovered from roof rats, but only eight from Norway rats, as shown in Table 1. Fewer Norway rats were handled, so that its list is probably incomplete; for example one would expect eventually to recover the cat flea, *Ctenocephalides felis* (Bouché), and the mouse flea, *Leptopsylla segnis* (Schonherr), from this host. Nevertheless there is a tendency

PLATE II

UPPER: Simple maze-type rat feeder; gathering cage not shown
LOWER: Interior of the open colony

for the Norway rat's ectoparasitic populations to be much more monotonous than those observed on roof rats (see Table 1).

The burrowing activities of Norway rats apparently often lead it to harbor more individual ectoparasites than the typical roof rat. In the case of fleas, and possibly mites, this is understandable, since these organisms frequently

TABLE 1.—*Ectoparasites encountered on roof rats and Norway rats in Florida*[1]

ECTOPARASITE	ON ROOF RATS	ON NORWAY RATS
Mites:		
Liponyssus bacoti (Hirst)	X	X
Laelaps nuttalli (Hirst)	X	X
Laelaps echidninus (Berlese)	X	X
Haemolaelaps glasgowi (Ewing)	X	
Androlaelaps setosus Fox	X	
Cosmolaelaps gurabensis Fox	X	
Radfordia ensifera (Poppe)	X	
Cheyletus eruditus (Schrank)	X	
Eutrombicula batatas (Linnaeus)	X	
Ticks:		
Dermacentor variabilis (Say)	X	
Amblyomma maculatum Koch	X	
Haemaphysalis leporis-palustris (Packard)	X	
Lice:		
Polyplax spinulosa (Burm.)	X	X
Hoplopleura oenomydis Ferris		X
Fleas:		
Xenopsylla cheopis (Rothschild)	X	X
Echidnophaga gallinacea (Westwood)	X	X
Leptopsylla segnis (Schonherr)	X	
Ctenocephalides felis (Bouché)	X	
Polygenis gwyni (C. Fox)	X	X
Cutaneous maggots:		
Cuterebra sp.	X	

[1] Grateful acknowledgment is made to the following individuals for identification of certain of the ectoparasites: Edward W. Baker, U. S. National Museum, for some of the mite determinations; Henry S. Fuller, Harvard School of Public Health, for the *Eutrombicula batatas* determination; Glen M. Kohls, Rocky Mountain Laboratory, for tick determinations; and Curtis W. Sabrosky, U. S. National Museum, for the *Cuterebra* sp. determination. The remaining identifications were made by the writer.

develop in the burrow itself. A comparison of some extensive data on this point revealed that the average number of fleas on an infested Norway rat was 6.4, while a roof rat harbored only 4.2. A higher percentage, 72.0 per cent, of flea-free roof rats was encountered than of Norway rats, 57.2 per cent. It is to be noted further that the roof rat's rural distribution leads it to acquire a number of ectoparasites that normally inhabit native wild animals. This is seen in the records of chiggers and rabbit ticks on roof rats, whereas the only such instance

thus far observed in Norway rats is in the case of *Polygenis gwyni* (C. Fox), a wild-rat flea.

Colonies.—In order to gain some information on the life history of roof rats, a natural colony that could be followed closely for a period of one year was established. A vacant tumble-down building full of holes for entry and exit was located in a semirural setting and was prepared for rat occupancy by filling it with trash from a near-by dump. Wooden boxes, old tires, tin cans, scrap lumber, paper, cardboard, hay, and brush were distributed along the walls, in corners, and across overhead rafters. This chaos is shown in Plate II, lower. Dog chow pellets were provided in unlimited supply, and watering pans were disposed in several places.

One hundred roof rats, comprising 36 males and 64 females, were trapped, bled, combed, DDT-dusted, toe-clipped, and then held in cages preparatory to liberation. When the blood tests were negative for typhus and when the animals had become accustomed to the dog chow diet, the cages were moved into the littered building. The animals were then starved for 24 hours, so that their first impulse on being released would be to feed on the lavish supply of chow. The cage doors were finally opened in the early evening.

Trapping stations were established in concentric circles around the building at intervals of 100 feet, most traps being concentrated in a line that led toward the dump and a few additional buildings beyond. Peripheral trapping every night during the first two weeks resulted in the capture of seven of the rats, most of them within 300 feet of the point of release.

It was decided to sample the population by retrapping rats in the building and peripherally at monthly intervals. To accomplish this, a feeding device, based on the familiar wire cage rat trap, was constructed. As shown in Plate II, upper, this had three drop pans leading into the feeding chamber and a fourth serving as an exit. Normally the exit was truly a route to freedom, but on trap-nights it led into a gathering cage from which the animals could be removed for identification on the following morning. Three such units were prepared, and it was soon apparent that the rats entered them readily.

Recovery of rats was at a low rate. At the end of the first month only seven of the females and nine of the males were taken in the building, and two females and two males peripherally. Four other females turned up later, three in the building and one peripherally, while no additional males were taken. Two females were trapped for six months, consecutively, one for five months, two for two months, and seven only at the end of the first month. Two males were caught for four months, five for two months, and five only at the end of the first month. The last of the original rats taken in a feeder trap was a female, retrapped for the first time nine months after liberation, and disappearing after the tenth month.

Young rats, born in the building, were toe-clipped for subsequent identification. They exhibited an even more tenuous residency, the majority of them appeared in the gathering cages only once. One female remained for seven months, one for four months, two for three months, four for two months, and

22 were caught only once. Two males remained for four months, two for three months, four for two months, and 17 were caught only once.

The total catch within the building, including adults and young, exhibited the following monthly pattern from November to October, consecutively: 16, 10, 9, 10, 11, 11, 12, 13, 7, 3, 14, and 11. The first young rats were taken two months after liberation of the adults.

A few rats were recaptured at the same peripheral stations more than once. The near-by dump, previously mentioned, was adopted by one female rat which was trapped there for the first five months. Two other male rats, caught peripherally, were taken less regularly during the same period. One female, unaccounted for since liberation, was trapped peripherally in the eighth month; this animal died, which prevented further observation. A few Norway rats inhabited the dump, and it was thought likely that they would invade the building with its ample food and shelter. This species was never taken there, however, perhaps due to the fact that the structure was erected on low pilings and was, therefore, not very suitable for the digging of protected burrows.

A check was maintained on the acquisition of ectoparasites by the vermin-free roof rats in the building. The near presence of Norway rats, plus the likelihood that the roof rats foraged outside the building at night, made it inevitable that parasites would eventually be encountered.

Four months after liberation three of ten rats were parasitized, two with *Liponyssus bacoti* and one with *Xenopsylla cheopis*. After five months two of 11 rats had *X. cheopis*. At six months no ectoparasites were seen. At seven months two of 12 rats had *X. cheopis*. At eight months seven of 13 rats were parasitized, there being some multiple infestations: four had *Polyplax spinulosa*, three had *X. cheopis*, one had *L. bacoti*, and one had a *Cuterebra* sp. maggot in its skin. At nine months six out of seven rats were parasitized, all of these with *X. cheopis* and one with *Polygenis gwyni*. At ten months two out of three rats had *X. cheopis* and *L. bacoti*. At eleven months all 14 rats had *X. cheopis*; one rat had a tick as well. At twelve months seven of 11 rats had *X. cheopis* and *P. spinulosa*. At no time did the ectoparasitic populations reach high levels; the maximum number of fleas observed on an animal was about six, lice about 20, and mites only three or four.

At the close of the study of this colony, the feeder traps were set every night for a week. In addition, numerous box traps, baited with horse feed and apple, were disposed along the walls. As might have been expected, more rats were caught than by the previous single-night monthly samplings. However, none of the original missing 76 animals turned up with the exception of one rat, which had been recovered regularly from the third to the ninth months, had then ceased entering the feeder trap on trap-nights and which was finally caught in a box trap. Having been an adult when liberated, it was now well over a year old. Four other rats, born in the building, but not recovered for the past four, five (two rats), and ten months, respectively, entered box traps. The remaining rats represented young adults or half-grown individuals either recently marked or now caught for the first time. Fifty-five rats in all were taken, and this was

considered to represent close to the maximum number that could get along together under conditions existing in the building.

The failure of this colony of rats to attain a denser population led us to establish a second colony, this time in a building ratproofed from the inside to prevent exit of the animals. Again food and water were furnished in unlimited abundance, but harborage was restricted to 30 nest boxes with hinged tops so that a complete census could be made at any time. Fifteen marked rats, ten females and five males, were liberated at the outset. Censuses were begun two weeks later and were continued at weekly intervals for 16 weeks, through August 8. Young litters were not included in the census totals, but were indicated by the letter "L." The weekly figures ran as follows: 12 + 2L, 12 + 1L, 12 + 1L, 14 + 1L, 16 + 1L, 15 + 1L, 16 + 5L, 24 + 4L, 20 + 5L, 22 + 3L, 28 +2L, 32 + 3L, 27, 30, 26 + 2L, and 29 + 2L.

In accord with the situation suggested by these figures, we observed that young weaned rats suffered a high mortality when they left the nest boxes. Moreover, there were serious losses among very young litters for which we could not account with certainty. It is possible that our opening the boxes in making a census disturbed parturient females sufficiently to cause them to destroy their young, although every effort was made to alarm the mothers as little as possible. Young litters were found to have been moved from one nest box to another on a number of occasions, and at other times rats only a few days old were found dying in exposed situations. A more likely possibility for the loss of young litters would be the intrusion of strange rats into a nest box while the mother was out feeding. Evidence of severe fighting, which could naturally result from such an affair, was abundant; the males in particular were often observed to have mutilated, swollen, and infected tails.

At this stage of the investigation it was decided that the population had reached a point of saturation with respect to the scanty amount of harborage provided. Hence a large quantity of trash was introduced into the building, especially to afford protection to young rats reaching the weaned stage and venturing outside their nest boxes. Results of this maneuver still await determination.

Breeding.—It is generally believed that wild-caught commensal rats are difficult to breed in captivity, although a few reports of successful breeding have appeared in the literature (Worden, 1947). Having seen evidence of abundant breeding in the periodic presence of human beings in the two foregoing colonies, we attempted to rear roof rats in cages. Although this was done on a rather small scale, it appeared that no obstacles to breeding were present. Even a pregnant roof rat, trapped only a few days before term, would rear her litter without untoward incidents. In one case we had a male and two females confined to a cage for some weeks. Both females littered at about the same time, and they continued to get along well with each other and with their mutual mate. When the young were about ten days old, the cage door was left open inadvertently over night. On the following morning the mothers were in the cage, each faithfully covering her litter, while the male was found behind another

cage only two feet away. Half-gallon pickle jars make excellent nesting compartments.

Behavior.—Our animal caretakers have become expert in handling many species of rats. They wear heavy leather gloves for all kinds, but, nevertheless, they report a wide difference in the response of rats to being picked up, an attitude with which the writer agrees, having handled a considerable number of the animals himself. The Norway rat is by far the most fierce and dangerous, exhibiting a high degree of aggressiveness and an indisposition to become tame. It is of interest that the three subspecies of the roof rat are distinctly at variance among themselves in the matter of docility. The fruit rat is the greatest fighter, the alexandrine rat somewhat less so, while the black rat almost approaches being gentle. Native wild rats are the tamest of all, however, with the cotton and rice rats even more easily handled than black rats, and the Florida wood rat the most gentle of all.

Nonbreeding roof rats may be kept in large numbers within relatively small cages, with only small losses due to fighting. For example, 25 animals have been kept for months in a cage only three feet square and 10 inches high.

A roof rat placed in a cage with a Norway rat merely retreats to the opposite side. If they are starved, the Norway rat will kill the roof rat. Placed with a white mouse, the roof rat may eventually kill it after several days, but generally it ignores its small companion.

Diet.—Our captive laboratory roof rats have fared very well on the dog chow ration without any additional supplement. Some of them were maintained for over a year on this diet and remained in good condition. In the wild they consume a wide variety of staples, but probably not acorns; since roof rats are abundant in some areas in Tampa where oak trees abound, it was considered possible that they subsisted, at least in part, on these nuts. Accordingly several roof rats were confined to cages and given nothing but acorns. They behaved as if this food item was foreign to their experience, one of them actually starved to death in the midst of plenty. It was proved that acorns are not poisonous to roof rats when some of the hungry rats discovered at last that there was nutriment within those hard shells. They were able to eat and to survive. They did not seem to relish the meat, but ate only enough to stay alive. Cotton rats, given only acorns, ate them at once and in quantity.

Discussion.—The complete disappearance of 76 of the 100 rats liberated in the open building deserves consideration. Even if it is assumed that our efforts to render the environment attractive to rats were far short of adequate, one must still wonder why more of the departing animals were not intercepted by the peripheral traps. It is possible, in view of the observed ability of roof rats to adopt a feral existence, that most of them migrated away from the dump and the buildings beyond, rather than toward them. But the few peripheral traps stationed in the opposite direction took no rats at all.

The work of Calhoun (1948) on populations of adult Norway rats throws some light on what may have happened in the first few days following liberation of our roof rats. These adult animals had not grown up together as a colony and

were, therefore, intolerant of each other. Thus it is possible that the dominant rats took possession of the building and drove out those that were unable to achieve a sufficiently high position in the social hierarchy.

In any event, the history of the rats that remained in the building indicates that this species does not tolerate a dense population in its breeding areas. Evidence from the closed colony further supports this idea, as also does field experience in trapping roof rats; not more than one or two families of rats were taken in the average residence, and large numbers were taken simultaneously only where they had an adequate amount of territory in which to range, such as on some farms. An exception to this is noted below.

That the roof rat, once established in a territory, does not wander far, but tends to remain at home if possible, is indicated by some of the data presented for the open colony. A small amount of additional evidence was obtained by trapping, marking, and releasing roof rats in five representative Tampa residential districts. Most of these animals were retrapped in the original garage or premise, or else next door, or perhaps across a narrow back alley. Very few were retaken as far as a block away or across a main street. These results, although fragmentary, accord well with the findings on Norway rats in Maryland (Davis, Emlen, and Stokes, 1948).

In contrast to this similarity, however, are the observations of feral roof rat populations, which are the result of wandering and dispersal of roof rats for long distances. These rats, of course, must also establish a home range, but this territory may be regarded as two- rather than three-dimensional as in the case of rats occupying buildings. The territory is thus probably of greater linear extent. Furthermore the feral roof rat must obviously cover more ground in the search for food than its commensal relatives, since concentrated deposits such as masses of garbage or grain are not to be found. Our animal caretakers have noted that fruit rats that accidentally escape are more fleet than any other rat; this may be because they often inhabit a more feral domain. Thus the rural roof rat, invading open ground removed from farm buildings, must adopt at least some of the behavioral characteristics of a native wild rodent.

The relatively low populations in the two breeding colonies, apparently indicating the saturation point under existing conditions, may seem to be somewhat at variance with other field observations. For example, an agent of the United States Public Health Service, who trapped rats in Hillsborough County, showed the writer a small enclosure in a dairy barn where he had gassed 144 roof rats. He quoted other cases in which he had encountered hundreds of these rats within a small space in large buildings. It is to be pointed out, however, that none of these rats were breeding in such locations, but used them more as dormitories. Apparently the species is gregarious or social outside its home range, but maintains a strict patrol of its nesting area. Thus we were unable to establish more than a few breeding females in our rat buildings, whereas we could easily keep 25 nonbreeding animals together in a small cage.

Roof rats readily learn to run a simple maze, as proved by their utilizing the type of feeder employed in the open colony. They seem capable also of learning

that under certain conditions this feeder is a trap. Of the four rats caught at the end of the study, but not caught for some months previously, one began to avoid the trap after being caught six times, the other three after being caught but once. At the time of final trapping one of these animals had apparently remembered its lesson for ten months.

Presumably there is wide variation in these rats' ability to learn or in their reactions to experience. Animals "repeating" in the traps for six or seven months, then disappearing, and not being recovered in the final trapping campaign, had probably died after the last time they were seen; possibly they would never have learned to associate the gathering cage at the feeder's exit with being caught. There were three such cases. But in general it seemed that the rats learned after one to four monthly experiences.

Summary and Conclusions.—1. The three subspecies of *Rattus rattus* in Hillsborough County, Florida, are distinguished by behavioral as well as color differences. The black rat, *R. r. rattus*, is probably the most susceptible to domestication.

2. At times roof rats can be found leading a feral existence. This species has a less tenacious association with mankind than does the Norway rat.

3. Roof rats acquire a greater number of kinds of ectoparasites than do Norway rats in Hillsborough County, owing to their wide rural distribution.

4. Norway rats are more frequently found infested with ectoparasites than are roof rats, and have higher average infestations, presumably because they live in burrows much more frequently and are, therefore, closer to the source of newly emerged fleas or freshly molted mites.

5. Feral roof rats are often infested with ectoparasites from native wild mammals.

6. Feral roof rats have been trapped in association with cotton rats.

7. Roof rats outnumber Norway rats in Hillsborough County about five to one.

8. Norway rats are rare on farms in Hillsborough County, being confined chiefly to urban areas.

9. Attempts to establish dense colonies of adult roof rats were only partially successful, owing to the fact that only a few females would breed within a limited area. Other rats in the area were killed or driven away.

10. Wild-caught roof rats breed readily in captivity when maintained in pairs in small cages.

11. Dog chow pellets are a sufficiently adequate diet to keep roof rats in good condition. They do not like acorns.

12. Evidence is presented which suggests that roof rats vary individually in their speed of learning. Some roof rats appear to remember a lesson for many months.

LITERATURE CITED

Calhoun, John B. 1948. The development and role of social status among wild Norway rats (Abstract). Anat. Record, Philadelphia, 101: 694.

Davis, David E., and John T. Emlen, Jr. 1948. The placental scar as a measure of fertility in rats. Jour. Wildlife Management, 12: 162–166.

DAVIS, DAVID E., JOHN T. EMLEN, JR., AND ALLEN W. STOKES. 1948. Studies on home range in the brown rat. Jour. Mammalogy, 29: 207–225.

DONALDSON, H. H. 1924. The rat: Data and reference tables for the albino rat (*Mus norvegicus albinus*) and the Norway rat (*Mus norvegicus*). Mem. Wistar Inst. Anat. and Biol., No. 6.

EMLEN, JOHN T., JR., AND DAVID E. DAVIS. 1948. Determination of reproductive rates in rat populations by examination of carcasses. Physiol. Zoöl., 21: 59–65.

EMLEN, JOHN T., JR., ALLEN W. STOKES, AND CHARLES P. WINSOR. 1948. The rate of recovery of decimated populations of brown rats in nature. Ecology, 29: 133–145.

GRIFFITH, J. Q., AND E. J. FARRIS (ED.). 1942. The rat in laboratory investigation. Philadelphia: J. B. Lippincott Co.

RICHTER, CURT P., AND JOHN T. EMLEN, JR. 1945. A modified rabbit box trap for use in catching live wild rats for laboratory and field studies. Pub. Health Rep., 60: 1303–1308.

WORDEN, ALASTAIR N. (ED.). 1947. The care and management of laboratory animals. Baltimore: The Williams & Wilkins Co.

Box 4298, Tampa, Florida. Received January 26, 1950.

FAT METABOLISM IN THE ARCTIC GROUND SQUIRREL

BY CHARLES G. WILBER AND X. J. MUSACCHIA

The Arctic climate is difficult for any animal to endure; but for small mammals, like the ground squirrel, it is particularly formidable. Squirrels, as a result of their small size, suffer relatively enormous heat losses which must be sustained by the heat producing mechanisms of the animal. The common Arctic ground squirrel, *Citellus barrowensis* (Anthony, 1937), thrives in its northern habitat and hence it must have solved the problem of balancing the budget of heat loss versus heat production.

Since fat is the outstanding source of heat energy in the animal body, it was decided to study the types, amounts, and variations of fats in the various tissues of *Citellus* with the view to throwing some light on the general problem of adaptation of mammals to Arctic climates.

Materials and methods.—Specimens of the squirrel, *Citellus barrowensis* Merriam, were live trapped in various parts of Arctic Alaska; one group in July, the other in September. This species is typically a northern form and its range is quite extensive. Anderson (*in* Stefansson, 1929) gives an interesting account of the natural history of this species.

The nomenclature is somewhat confused. Preble (1908) lists it as "*Citellus* (*Colobotis*) *parryi kennicotti* (Roso)". Anthony (1937), on the other hand, uses the species name *barrowensis*. To add to the confusion, Hershkovitz (1949) maintains that "Cuvier's well known and hitherto universally employed *Spermophilus* 1825, must be revived for the ground squirrels currently referred to *Citellus*, a name improperly credited to Oken, 1816." If this contention is valid, the species used in the present work should be called *Spermophilus barrowensis*, a name given to the Point Barrow squirrel by Merriam (1900), but described as synonymous with *kennicotti* by Preble (1908).

A verbal communication from the American Museum of Natural History indicates that they use the name *Citellus barrowensis* for the species investigated by us. Until the consensus of nomenclatorial specialists is clearcut on this point, we will use the name *Citellus barrowensis*.

Chemical procedures.—Samples of the liver, kidneys, and blood were taken from the two groups of squirrels. Tissues were prepared for analysis and lipids were extracted according to Bloor's (1929) method. Total fatty acids were estimated, using the method of Bloor as modified by Snell (1937). Lipid phosphorus was estimated by a modified Youngburg (1930) technique; from these values phospholipid was calculated as lecithin. Measurements of cholesterol were based on methods developed by Bloor (1916).

All the procedures were colorimetric. A Coleman 6A spectrophotometer was used to measure color intensities. Lipid values for blood are expressed as mg. of lipid per 100 cc. of whole blood; for solid tissues, as per cent fresh tissue.

Results.—Table 1 summarizes the lipid values for the blood of the Arctic ground squirrel. Fatty acid values for specimens 104, 105, 106, and 107 are missing; the record sheets were destroyed by water in the field. The mean fatty acid is 833 mg. per 100 cc. of whole blood. The mean cholesterol is 223.9 mg. per 100 cc. of whole blood. Lipid phosphorus is 24.6 mg. per 100 cc. of whole blood. The latter value multiplied by 25 gives phospholipid (as lecithin) as 615 mg. per 100 cc. whole blood.

Table 2 shows the amounts of lipids in the liver of seven different ground squirrels collected during July and September, 1948. There is no apparent difference in cholesterol values for the two groups. A comparison of the mean values from Table 2 indicates, however, that the amount of fatty acids, lipid phosphorus, and phospholipid in the July group is appreciably greater than in the September group.

Table 3 shows the values for the lipids from the kidneys of the same squirrels listed in the previous table. Here again it is apparent that the cholesterol values are the same in the July and September (Table 3) groups. On the other hand, there is much more fatty acid and phospholipid in the kidneys of the early than of the late group.

Discussion.—Table 1 shows that the amounts of some of the lipids in the squirrel blood are relatively high, if compared with ordinary laboratory mammals. Bloor (1916) gives the following mean values, in mg. per 100 cc. whole blood, for the dog: total fatty acids, 590; phospholipid, 350; cholesterol, 230.

Cholesterol in the Arctic squirrel (223.9 mg. per 100 cc.) and in the dog are about the same. On the other hand, the total fatty acids and phospholipids in the squirrel, 833 and 613 mg. per 100 cc., respectively, are very high. These facts may be interpreted as indicating a high level of fat metabolism in the squirrel as compared with the dog.

A similar comparison with the rabbit (in which the lipids of whole blood are, in mg. per 100 cc.: total fatty acids, 340; phospholipid, 210; cholesterol 110) (Horiuchi, 1920) also shows that the level of fat metabolism is much higher in the squirrel than in the rabbit.

There are no apparent differences in amount of blood lipids in squirrels collected early in summer as compared with those collected in September. On the other hand, examination of the results of analyses (Table 2) shows that there are pronounced differences in the liver lipids from July and September squirrels. It

TABLE 1.—*The amounts of various lipids in the whole blood of Citellus barrowensis. Values are in mg. per 100 cc. of whole blood*

SPECIMEN	TOTAL FATTY ACIDS	TOTAL CHOLESTEROL	LIPID P
SS 104	—	200.0	—
105	—	266.4	25.5
106	—	231.0	17.1
107	—	214.4	10.7
108	1150	237.0	22.5
109	775	235.0	39.0
110	850	258.0	28.0
111	675	197.0	25.4
112	784	224.0	33.0
113	766	196.6	20.2
Mean	833	223.9	24.6

TABLE 2.—*The amounts of various lipids in the liver of the Arctic ground squirrels, collected during early July and September, 1948. Values are in per cent wet weight*

SPECIMEN	TOTAL FATTY ACIDS	CHOLESTEROL	LIPID P	PHOSPHOLIPID
		July		
SS 101	11.1	0.24	0.22	5.5
102	9.5	0.24	0.22	5.8
103	11.1	0.41	0.22	5.5
104	12.1	0.62	0.22	5.5
105	12.1	0.27	0.31	7.8
106	15.6	0.27	0.22	5.5
107	14.8	0.31	0.36	8.9
Mean	12.6	0.34	0.25	6.25
		September		
SS 108	3.8	0.24	0.13	3.29
109	3.8	0.33	0.16	3.98
110	4.7	0.34	0.16	3.95
111	3.8	0.29	0.14	3.38
112	4.5	0.34	0.15	3.65
113	4.7	0.34	0.15	3.65
Mean	4.2	0.31	0.15	3.75

is clear that cholesterol is essentially the same in each group. There is, however, about three times as much fatty acid and almost twice the phospholipid in the early as in the late specimens.

It is well known that the liver plays "a major part in the intermediary metabolism of fat, since its composition so accurately reflects every mobilization

of fat, whatever its cause" (Peters and Van Slyke, 1946). If this is true for mammals in general, it is apparent that in early summer the level of fat metabolism in the Arctic ground squirrel is high. The high fatty acid and phospholipid content of the liver at that time indicates a very active rate of fat turnover. The evidence indicates that in September the rate of lipid metabolism drops appreciably.

TABLE 3.—*The amounts of lipids in the kidneys of the Arctic ground squirrels collected in 1948. Values in per cent wet weight*

SPECIMEN	TOTAL FATTY ACIDS	CHOLESTEROL	LIPID P	PHOSPHOLIPID
		July		
SS 101	16.6	0.25	0.31	7.75
102	16.6	0.31	0.18	4.5
103	7.4	0.33	0.16	4.0
104	9.9	0.35	0.26	6.5
105	9.9	0.33	0.24	6.0
106	9.2	0.36	0.21	5.3
107	9.9	0.37	0.27	6.75
Mean	11.4	0.34	0.23	5.83
		September		
SS 108	3.55	0.46	0.16	3.98
109	4.1	0.36	0.22	5.5
110	3.4	0.45	0.15	3.7
111	2.46	0.26	0.10	2.5
112	3.3	0.29	0.16	4.0
113	3.3	0.45	0.14	3.5
Mean	3.85	0.38	0.16	3.86

TABLE 4.—*The lipid ratios for various tissues from the Arctic ground squirrel*

TISSUE	CHOLESTEROL/ FATTY ACID	CHOLESTEROL/ PHOSPHOLIPID	CHOLESTEROL/ LIPID P	FATTY ACID/ LIPID P
Whole blood	0.27	0.36	9.1	33.9
Liver				
July	0.027	0.052	1.36	50.4
September	0.074	0.082	2.00	28.0
Kidneys				
July	0.03	0.055	1.48	49.1
September	0.1	0.1	2.38	24.0

These clear-cut changes may be correlated with the preparation, by the squirrel, for the long hibernation. From our own observations, and those of Anderson (*in* Stefansson, 1929), it is known that the Arctic squirrel goes into hibernation in late September; it comes out about the middle or end of April. During the short spring and summer, fat must be stored quickly as reserve for the winter. The present study of liver lipids indicates that this fat storage is progressing at a fairly rapid rate in July, and that by mid-September it has fallen off markedly.

In many respects the kidneys of most animals behave toward lipids in a manner much like the liver does. Table 3 shows such parallel behavior of the kidneys of *Citellus barrowensis* towards lipids. In the kidneys of squirrels collected in July there is more fatty acid and phospholipid than in those collected in September. Cholesterol is the same in both groups and quite similar to liver cholesterol. The absolute values of fatty acids and phospholipids are lower in the kidneys than in the liver.

In evaluating the results of lipid analyses the ratios of one lipid to another are often enlightening. The following ratios for squirrel blood, kidney, and liver were calculated: cholesterol/fatty acid; cholesterol/phospholipid; cholesterol/lipid P; fatty acids/lipid P. The results are tabulated in Table 4.

Mayer and Schaeffer (1913) maintain that the higher the ratio, cholesterol/lipid phosphorus, the greater water content of the tissue in question. If this contention is universally true, there is an increase in water content of both liver and kidneys in the Arctic ground squirrel as the time of hibernation approaches.

A study of these ratios indicates that the early squirrels contain the same amount of fatty acids in proportion to lipid phosphorus in both liver and kidneys. As hibernation approaches, less fatty acid is found, in relation to lipid phosphorus. Moreover, this decrease in fatty acid, relative to lipid phosphorus, is greater in the kidneys than in the liver.

The ratio of cholesterol/fatty acid is almost the same for liver and kidneys in the early squirrels. As hibernation approaches, the amount of fatty acid, relative to cholesterol, decreases; and their decrease is greater in the kidneys than in the liver.

The entire picture suggests a rapid rate of fat metabolism in the Arctic squirrels during the short summer months, with a gradual decrease in lipid turnover as hibernation approaches.

Wade (1948) maintains that the Nebraska ground squirrel, *Citellus tridecemlineatus*, has a remarkable ability for fat storage. He suggests that the ground squirrels have an extremely efficient mechanism for food absorption and fat metabolism. He further concludes that this process is an adaptive mechanism associated with hibernation.

The present biochemical investigation of the Arctic ground squirrel demonstrates that this species, also, exhibits a high level of fat production and storage. It may be that this mechanism is adaptive in nature and makes for survival of these small mamals in a very rigorous climate.

One sample of ground squirrel depot fat (subcutaneous) was analyzed with the following results: (specimen SS113) fatty acids, 28.8 per cent; cholesterol 0.1 per cent; lipid phosphorus, 0.01 per cent; phospholipid 0.25 per cent. Whether this gives a true, general picture of all the depot fat cannot be concluded at this time.

Summary.—A study was made of the lipids in the blood, liver, and kidneys of the Arctic ground squirrel, *Citellus barrowensis*, collected at different times of the year.

No differences in cholesterol content of the tissues were observed in any of the squirrels.

Fatty acid, lipid phosphorus, and phospholipid are in greater concentration in tissues from squirrels collected in July than in those collected in September.

The results indicate that there is a relatively high level of lipid metabolism in the Arctic squirrel and that fat turnover is appreciably greater in July than in September.

It is suggested that these changes may be correlated with preparation for long winter hibernation.

LITERATURE CITED

ANTHONY, H. E. (ED.) 1937. Animals of America. Mammals of America. Garden City Publ. Co., Garden City, N. Y., 335 pp.

BLOOR, W. R. 1943. Biochemistry of the fatty acids. Reinhold, New York., 387 pp.

——— 1916. The determination of cholesterol in blood. Jour. Biol. Chem., 24: 227–231.

——— 1929. The oxidative determination of phospholipid (lecithin and cephalin) in blood and tissues. Jour. Biol. Chem., 82: 273–286.

HERSHKOVITZ, P. 1949. Status of names credited to Oken, 1816. Jour. Mamm., 30: 289–301.

HORIUCHI, Y. 1920. Studies on blood fat. Jour. Biol. Chem., 44: 345–361.

MAYER, A., AND G. SCHAEFFER. 1913. Recherches sur la teneur des tissus en lipoides. Jour. Physiol. Path. Gen., 15: 771–788.

MERRIAM, C. H. 1900. Descriptions of twenty-six new mammals from Alaska and British North America. Proc. Wash. Acad. Sci., II: 13–30.

PETERS, J. P., AND D. D. VAN SLYKE. 1946. Quantitative clinical chemistry. Interpretations. Vol. 1. Interpretations. Baltimore. Williams and Wilkins, 2nd ed. 1041 pp.

PREBLE, E. A. 1908. A biological investigation of the Athabaska–Mackenzie Region. N. Amer. Fauna, No. 27: 574 pp.

SNELL, F. D., AND C. T. SNELL. 1937. Colorimetric methods of analysis. Van Nostrand, New York, 766 pp.

STEFANSSON, V. 1929. My life with the Eskimo. Macmillan, New York, 538 pp.

WADE, O. 1948. Rapid fat production by ground squirrels preceding hibernation. Nat. Hist. Miscl., Chicago Acad. Sci., No. 28: 3 pp.

YOUNGBURG, G. E., AND M. V. YOUNGBURG. 1930. Phosphorus metabolism. I. A system of blood phosphorus analysis. Jour. Lab. Clin. Med., 16: 158–166.

[The work on which this report is based was supported by the Arctic Institute of North America with funds provided by the Office of Naval Research.]

Biological Laboratories, St. Louis University, St. Louis, Missouri, and The Arctic Research Laboratory, Point Barrow, Alaska. *Received November 17, 1949.*

MAMMALS OF A NORTH FLORIDA SWAMP

By George H. Pournelle

Several papers have appeared within the past few years dealing with regional studies of the mammals of Florida: Blair (1935), Hamilton (1941), Rand and Host (1942), Moore (1946, 1949), and Ivey (1947). Published data, however, concerning the mammals of a swamp area have been limited chiefly to Francis Harper's work on the Okefinokee Swamp in southern Georgia and northern Florida (1927).

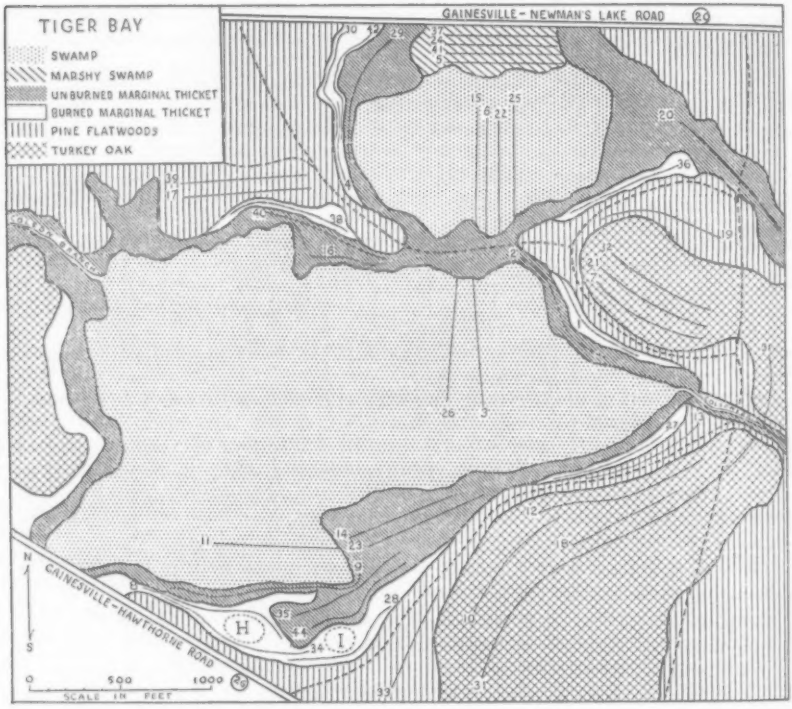

Fig. 1.—Map showing vegetation types and traplines in the Tiger Bay area.

This report is the result of an investigation of the mammalian fauna of a north Florida swamp made during the latter part of 1941 and from May until December of 1946. The assistance, in various ways, of many people is gratefully acknowledged. Dr. H. B. Sherman has furnished valuable aid, both in the course of the study and in preparation of the manuscript. Dr. J. Speed Rogers made available an assistantship at the University of Florida while work was in progress. Dr. A. M. Laessle has identified plants and made three trips in the field

to aid in determining the plant communities. Dr. C. J. Goin has furnished data concerning the study region with which he has been familiar for many years. Dr. T. H. Hubbell, Mr. Erdman West, and Mr. J. C. Dickinson have aided in the identification of mammalian stomach contents.

The study area includes approximately 400 acres of land, 150 acres of which form a swamp known locally as Tiger Bay. It lies about two and one-half miles east of the Alachua County courthouse in Gainesville, and is in the angle formed by state highways 20 and 26 in Sections 2 and 11, Township 10 South, Range 20 East. The general distribution of the plant communities is given in the accompanying map (Fig. 1).

The Gainesville area is included in the topographical division of Florida known as the Central Highlands, which extends down the central part of the state to a level just north of Glades County and ranges from less than 40 feet to 325 feet above sea level (Cooke, 1939; 23). At the courthouse in Gainesville the elevation above sea level is 165 feet. From here the land slopes gently eastward to 70 feet at the shores of Newman's Lake. Tiger Bay, which is about midway between these places, is at an elevation of about 125 feet, as shown by the Florida Arredonda Sheet of the U. S. Geological Survey.

Four plant communities, determined by the relative abundance of common plants, are recognized in this study: *Swamp*, *marginal thicket*, *pine flatwoods*, and *turkey oak*. The influence of man has played a rather important role in upsetting normal successions and rendering many areas difficult to classify. Annual burning and occasional lumbering have created a botanical hodgepodge of some spots and arrested succession in others. The marginal thicket, for instance, is present in two distinct phases as a result of fires invading the dryer areas, and places that were originally swamp are in a semi-marsh condition due to the cutting of timber. For plant nomenclature the following sources are used: For ferns, Small (1931); for trees, West and Arnold (1946); and for all other plants, Small (1933).

PLANT COMMUNITIES

The *swamp* is an area dominated by pond cypress (*Taxodium ascendens*) and tupelo gum (*Nyssa sylvatica biflora*). Other common trees are slash pine (*Pinus elliotti*), loblolly bay (*Gordonia lasianthus*), red maple (*Acer rubrum*), and southern sweet-bay (*Magnolia virginiana australis*). Except during extremely dry weather the ground is covered by a foot or more of water from which arise small islands varying from a couple of feet to twenty or more feet in diameter. Though the interior is, generally speaking, fairly open, there are patches of dense, shrubby undergrowth occurring chiefly around the fringes. These are made up of buttonbush (*Cephalanthus occidentalis*), fetterbush (*Desmothamnus lucidus*), blaspheme vine (*Smilax laurifolia*), and blackberry (*Rubus* sp.), the latter two forming dense, almost impenetrable tangles. To the south, fronting the highway, are small local patches of marsh dominated by cattail (*Typha angustifolia*). Water plants such as poison-arum (*Peltandra virginica*), pickerel-weed (*Pontederia lanceolata*), and alligator bonnet (*Castalia oderata*) grow in abundance. During the summer months numerous ferns, the regal fern (*Osmunda regalis*), chain fern (*Anchistea virginica*), and others, lend much to the beauty of the place.

There is an area bordering highway 20 that was formerly swamp, but removal of the trees has left it in a semi-marsh condition. It is included in the swamp community for convenience and referred to as marshy swamp. Here the ground is submerged, as in the swamp proper, and there are a few young slash pine and cypress saplings present with undercover being made up largely of chain fern and sawgrass (*Mariscus jamaicensis*).

The *marginal thicket* is a band of varying thickness surrounding the swamp, encroaching

deeply into it in places, almost nonexistent in others, and presenting a quite varied aspect. It is split into two phases as a result of the yearly firing of the surrounding pinelands by the local cattlemen in January and February to improve grazing conditions for their stock. Though the ground of the outer rim is quite saturated in places during the summer months, a condition of arrested growth prevails because of the annual winter burnings. Waxmyrtle (*Myrica cerifera*), fetterbush, and Virginia-willow (*Itea virginica*), which are quite conspicuous in unburned areas, are here kept in a retarded stage. This condition permits the flourishing of a conspicuous herbaceous flora of annuals consisting of fringe orchids (*Blephroglottis*) of several species, club mosses (*Lycopodium alopecuroides*), pitcher plants (*Sarrecenia minor*), cinnamon ferns (*Osmunda cinnamomea*), and numerous grasses and sedges. Sphagnum moss (*Sphagnum* sp.) forms a mat over a great portion of this area and dominant trees are the slash pine and pond pine (*Pinus rigida serotina*). Saw palmetto (*Serenoa repens*) is found abundant in both burned and unburned areas. Although much of this area is flooded during the summer and early fall, at other times of the year only a moist condition of the ground prevails. To the north, fronting the road, adjacent to the marshy area, waxmyrtle and coastal plain willow (*Salix longipes*) form dense thickets. Waxmyrtle also occurs throughout the marginal thicket, but not in such heavy stands.

The *pine flatwoods* are present in very narrow, poorly defined bands along the eastern border of the swamp, merging abruptly into turkey oak or marginal thicket depending on slight changes in elevation. To the south there is only a very narrow strip fronting the road. On the northern and western sides of the swamp larger areas are present. All of this community is subject to annual burning and is marked by a much greater paucity of shrubby undergrowth and trees than is undisturbed flatwoods. The longleaf pine (*Pinus palustris*) is dominant except in low areas where it is replaced by slash pine and pond pine. Gallberry (*Ilex glabra*), wire grass (*Aristida stricta*), stagger bush (*Xolisma fructicosa*), saw palmetto, and huckleberry (*Cyanococcus myrsinites*) make up a large part of the undercover. Isolated patches of marginal thicket growth exist in low areas where the ground remains saturated for long periods.

The *turkey oak* community covers the highest parts of the area. The ground is exceedingly dry, undercover is sparse, and large patches of bare sand are much in evidence. The turkey oak (*Quercus laevis*) is the dominant tree of this community; a few large longleaf pines are present. Saw palmetto, gopher apple (*Geobananus oblongifolius*), and an occasional pawpaw (*Pityothamnus reticulatus*) are the most conspicuous shrubs. Ground cover is formed, for the most part, by wire grasses (*Aristida stricta* and *Sporobolus gracilis*), Indian reeds (*Sorghastrum secundum*), and partridge peas (*Chamaecrista brachiata* and *Chamaecrista procumbens*). The soil is characterized by high porosity which allows rapid dissipation of surface water. This condition is favorable to fossorial animals, and consequently pocket gopher mounds as well as gopher-tortoise dens are abundant.

Methods:—Data concerning the mammals of the area were collected by several methods of which trapping proved most productive. Observations of captive animals, night observations in the field, and hunting were also employed, together with information contributed by others.

Four types of traps were used: The small Sherman live trap proved most useful for the capture of small live specimens. A slightly larger metal trap with a wire bottom (Sherman, 1941) was useful in collecting live pocket gophers. For large mammals, steel jump traps were used. Some snap traps were employed, but they were discontinued because they were not large enough to capture the larger rodents, such as rice rats and cotton rats. Smaller rodents and shrews were almost invariably caught across the head with a damaged skull resulting. A mixture of chopped raisins, peanut butter, and oatmeal was the usual bait for live traps; cornmeal was used on several occasions. Mice remains and fish scraps were used to bait the steel traps.

Marked specimens furnished data of fundamental importance. At the outset a combination of toe clipping and ear punches was used. Beginning in 1946 ear punches were used entirely, following the method described by Blair (1941; 52). Data concerning movements of

the cotton mouse, cotton rat, and rice rat are included under the accounts of species, and that on distribution and abundance of the mammals is summarized in Tables 4 and 5.

ACCOUNTS OF SPECIES

Didelphis virginiana pigra Bangs. Opossum.—Three opossums were taken during the month of August, 1946. One was taken in the swamp, one in unburned thicket at the edge of Colson Branch, and one was killed by a car just opposite the turnoff into the area where a fringe of pine flatwoods borders the road. I have found tracks of this species by Colson Branch and in the sand of the road along the eastern border of the swamp.

An examination of the stomach of the specimen killed on the highway yielded the following identifiable contents: Scuppernongs (*Muscadinia rotundifolia*), a cockroach (*Pycnoscelus aurinamensis*), dragonfly (*Sympetrum* sp.), cicadid (*Tibicen* sp.), frog-hopper (*Monecphora bicincta*), wasp (*Hemipogonium* sp.), a beetle, lepidopterous caterpillars, flesh-flies, a velvet ant, a toad (*Bufo* sp.), and a bird (Turdidae). Several parasitic roundworms were taken from the pyloric end of the stomach.

On several nights I have hunted with dogs in Tiger Bay, but without success, and I suspect that oppossums are not abundant there. A hunter, Mr. R. Stanridge, told me that he had taken two females with young in their pouches during the first week of August, 1946, about two miles north of Tiger Bay.

Cryptotis floridana (Merriam). Least shrew.—Seven specimens of this shrew were obtained; four in marginal thicket and three in flatwoods. Their weights ranged from 4.2 to 4.3 grams.

One specimen, captured on July 17, 1946, contained two embryos, the crown-rump measurements of which were five and six millimeters, respectively.

Blarina brevicauda carolinensis (Bachman). Short-tailed shrew.—A young female was taken by Dr. B. A. Barrington, Jr. on December 12, 1939, at the base of a waxmyrtle in the marshy swamp area. I caught a breeding male (judging from the appearance of the testes) in unburned thicket on the south side of the swamp on October 14, 1946. These two specimens weighed 5.5 and 10 grams, respectively.

Pipistrellus subflavus subflavus (F. Cuvier). Pipistrelle bat.—Two males were shot on the evening of September 24, 1941, as they came out of the eastern side of the swamp.

Lasiurus seminolus (Rhoads). Seminole bat.—A male seminole bat was shot September 24, 1941, by Dr. F. N. Young as it came out of the swamp.

Procyon lotor elucus Bangs. Raccoon.—A raccoon was seen on the night of August 13, 1946, at 9:00 P.M. It crossed the highway from marginal thicket and disappeared into the marshy swamp. Raccoons are apparently rare here, probably because of the activities of hunters. Small traps have never been molested in Tiger Bay, whereas in similar places farther removed from human habitation raccoons have been pests. They have followed my trap lines, sprung and overturned traps, and even removed captured animals.

Mustela frenata peninsulae (Rhoads). Long-tailed weasel.—Dr. Goin furnished me with the sole record for this species for the area. He found one dead on the highway southwest of the swamp in 1940.

Lutra canadensis vaga Bangs. Florida otter.—George Saunders, an old negro resident of this area, told me that he cornered an otter in a hollow cypress in the swamp. It fought off his dogs and succeeded in escaping. R. DeWitt Ivey reported seeing an otter cross the road 1½ miles east of Tiger Bay during the early summer of 1946.

Sciurus carolinensis carolinensis Gmelin. Gray squirrel.—Gray squirrels were observed in the swamp and marginal thicket. Their nests, of two types, were found in the above communities and also in pine flatwoods. One type of nest is compact and composed of a rather sparse framework of branches and twigs, a main body of Spanish moss, and a lining of finely shredded cypress bark. Four of these nests, one of which was being used by a gray squirrel at the time of examination, were examined in detail. Each had the entrance on the under side. Measurements through the largest diameters were: 16 by 11, 15 by 8, 18 by 9, and 15 by 9 inches. One contained a bumblebee's nest, several lepidopterous larvae, and

numerous mites and springtails. Three of the nests were in waxmyrtle; one was in a cypress sapling. All nests were in the same general area and were nearly identical in construction, so it seems safe to assume that they all belonged to the gray squirrel.

The other type of nest that the gray squirrel was observed to use is composed entirely of leaves and vines. I have found three of these, all in waxmyrtle. Ten nests, of one type or other, were observed in waxmyrtle, nine in cypress, and six in slash pine. In fully grown pine and cypress trees they were at an estimated height of fifty feet from the ground. On two occasions, shortly after dusk and in the middle of the morning, gray squirrels were flushed from their nests. When the nests were reexamined a few hours later, neither squirrel was present.

Gray squirrels in the area have been observed feeding on pine mast. While working in an area about two miles east of Tiger Bay, Blair (1935; 275) observed these animals feeding on the berries of the swamp tupelo; he was of the opinion that they ate the berries of the blaspheme vine as well.

Sciurus niger niger Linnaeus. Fox squirrel.—Dr. Goin shot one of these squirrels in the pine flatwoods along the northwestern edge of the swamp about eighteen years ago.

Glaucomys volans querceti (Bangs). Southern flying squirrel.—This species appears to be rare in the area. Only one record has been obtained although much time has been spent in searching for them. A nest was found in a small longleaf pine in the turkey oak community. It was about four inches in diameter and made of leaves with a lining of Spanish moss fibers. It was in a fork next to the main trunk about ten feet from the ground. Although this nest was unoccupied, it agreed in construction with others that I have found which contained flying squirrels.

Geomys tuza austrinus Bangs. Pocket gopher.—The pocket gopher is abundant in the turkey oak and appears in dryer pine flatwoods, but has not been found in lower moist marginal thicket areas. Two of these animals, taken in December, 1946, weighed 132.5 and 144 grams, respectively. Both were females; neither was pregnant or nursing.

Reithrodontomys humulis humulis (Audobon and Bachman). Eastern harvest mouse.—One adult male was taken in burned-over thicket on June 15, 1941.

Peromyscus gossypinus gossypinus (LeConte). Cotton mouse.—The cotton mouse is the most abundant mammal encountered in the Tiger Bay area. A total of 93 individuals, including 55 males, 26 females, 6 juveniles, and 6 of undetermined age and sex, was taken. The distribution of these mice according to ecologic communities is given in Table 5.

Regarding feeding habits, the cotton mouse seems to be quite omnivorous. Captive animals have accepted and eaten, with apparent relish, a variety of foods including bread, crackers, roaches, grasshoppers, spiders, and meat. Rand (1942; 19) found scales from myrtle berries and insect remains, including an ant, in the stomachs that he examined.

A cotton mouse, released in a tub of water, was adept at swimming. The body was kept horizontal at all times. The fore and hind limbs were used for paddling; the tail was useful as a sculling device. At no time did the animal seem to be in trouble though it was constantly swimming around the edge of the tub looking for a place of escape. Another animal was placed in a large jar of water and observed for an hour, during which time she swam almost continously, resting occasionally with her body held vertically with only the tip of the nose above water. At times she swam rapidly around the bottom of the jar and appeared to be searching for an underwater escape tunnel. There was no means of support in either the tub or the jar.

The climbing ability of the cotton mouse was also investigated. An individual was released on the bole of a tree about eight feet from the ground. It started immediately for the top of the tree, climbing in a spiral fashion in the manner of a squirrel. Here again the animal seemed perfectly at home.

The cotton mouse, although quite ubiquitous, prefers forested areas such as swamps and wet hammocks. These two accomplishments, swimming and climbing, are important to an animal living in a hydrophytic community such as a swamp, where the ground is submerged, or in a marginal thicket where both water and dense vegetation are present. These rodents

are fitted to meet the sudden fluctuations in water level brought about by heavy summer rains. As has been indicated, some of these communities are alternately dry and wet, at times completely submerged, and these changes can take place within a period of a few days.

Data concerning the movements of the cotton mouse result from recaptures of marked animals. Sixty-eight individuals were marked and twenty-six retaken (Table 1). Distances up to 2800 feet were recorded after an interval of seven days. The greatest distance recorded

TABLE 1.—*Movements of Peromyscus g. gossypinus*

TAG NO.	SEX	DATE MARKED	C	TL	FIRST RETAKE	C	TL	D	SECOND RETAKE	C	TL	D
2	f	6/12/41	BMT	1	6/19/41	TO	7	430				
3	m	6/12/41	BMT	1	6/17/41	UMT	2	300	7/30/41	PW	13	700
5	m	6/12/41	UMT	2	6/13/41	UMT	2	37				
8	m	6/12/41	S	3	6/19/41	BMT	1	500				
10	f	6/13/41	BMT	1	6/14/41	BMT	1	0				
12	m	6/13/41	S	3	6/17/41	S	3	148				
13	m	6/13/41	S	3	6/14/41	S	3	110	6/18/41	S	3	0
14	m	6/13/41	S	3	6/14/41	S	3	70				
18	f	6/13/41	S	3	6/17 41	BMT	1	600	6/18/41	BMT	1	0
19	m	6/14/41	UMT	2	6/16/41	TO	7	700	6/17/41	TO	7	110
22	m	6/15/41	S	3	6/19/41	UMT	2	810				
23	m	6/15/41	BMT	1	6/18/41	BMT	1	110				
25	m	6/16/41	S	3	6/27/41	UMT	9	1500				
28	m	6/17/41	BMT	1	6/19/41	UMT	2	200				
31	f	6/17/41	UMT	2	6/19/41	UMT	2	600				
32	m	6/18/41	BMT	1	6/25/41	BMT	8	2800				
36	m	6/19/41	BMT	1	6/26/41	UMT	9	1900	6/27/41	UMT	9	0
50	m	7/30/41	PW	13	7/31/41	PW	13	0				
51	m	7/30/41	PW	13	8/1/41	PW	13	0				
52	m	7/30/41	PW	13	7/31/41	PW	13	30				
55	f	7/30/41	PW	13	7/31/41	PW	13	0	8/1/41	PW	13	0
60	m	7/30/41	UMT	14	8/1/41	UMT	14	0				
61	m	7/30/41	UMT	14	8/1/41	UMT	14	150				
7a	m	7/15/46	PW	19	7/16/41	PW	19	400				
8a	m	7/15/46	BMT	H	7/16/46	BMT	H	130				
13a	m	10/13/46	BMT	I	10/16/46	BMT	I	130				

C = plant community; BMT = burned marginal thicket; UMT = unburned marginal thicket; S = swamp; MS = marshy swamp; PW = pine flatwoods; TO = turkey oak; TL = trapline; D = minimum distance traveled in feet.

for one night was 400 feet for an adult male in pine flatwoods. Moore (1942; 125) records a distance of 480 feet for an adult male in one night. Individuals apparently are not confined to any particular plant community in the area. Nine marked animals were retaken in associations other than the place of original capture. One adult male was taken in three different communities, the first time in burned thicket, again in unburned thicket, and finally in the flatwoods. Another male, marked in trapline 1 in burned thicket (Fig. 1), was retaken seven days later 2800 feet away in trapline 9, also in burned thicket. If this animal had traveled by the shortest route it would have had to cross two strips of unburned thicket and an extensive area of swamp in order to arrive at the place of second capture. Other movements are included in Table 1.

Peromyscus nuttalli aureolus (Audubon and Bachman). Golden mouse.—An adult female was taken from a palmetto clump in pine flatwoods on the east side of the swamp on July 30, 1941. She was not pregnant and did not appear to be nursing.

Oryzomys palustris natator Chapman. Rice rat.—Forty-five rice rats were taken from Tiger Bay, twenty-three of which were males, six were females, eleven were immatures of undetermined sex, and five were of undetermined age and sex. Immatures were taken in June, July, August, and February. Rice rats were found in greatest numbers in the marshy areas, though they were also taken in the swamp and unburned thicket, and occasionally

TABLE 2.—*Movements of Oryzomys palustris natator*

TAG NO.	SEX	DATE MARKED	C	TL	FIRST RETAKE	C	TL	D	SECOND RETAKE	C	TL	D
2	f	6/12/41	UMT	2	6/13/49	UMT	2	0				
5*	?	6/15/41	S	3	6/16/41	S	3	0	6/17/41	S	3	222**
9	m	6/15/41	MS	5	6/17/41	MS	5	0				
10*	?	6/16/41	MS	5	6/17/41	MS	5	37	6/19/41	MS	5	75
38*	?	6/25/41	UMT	9	6/26/41	UMT	9	270	6/27/41	UMT	9	37
40	m	6/25/41	UMT	9	6/26/41	UMT	9	75				

* Juvenile. ** Also taken 6/19/41 in trapline 3 in swamp with distance traveled of 222 feet. Abbreviations as in Table 1.

TABLE 3.—*Movements of Sigmodon hispidus hispidus*

TAG NO.	SEX	DATE MARKED	C	TL	FIRST RETAKE	C	TL	D	SECOND RETAKE	C	TL	D
37	m	6/26/41	UMT	9	6/27/41	UMT	9	150				
12*	m	7/15/46	BMT	28	7/17/46	BMT	28	120				
13*	m	7/15/46	BMT	28	7/16/46	BMT	28	30	7/17/46	BMT	28	60
15	f	7/15/46	BMT	28	7/16/46	BMT	28	0				
17	m	7/15/46	PW	19	7/17/46	PW	19	50				
18*	?	7/15/46	BMT	H	7/16/46	BMT	H	30	7/17/46	BMT	H	0
19*	?	7/15/46	BMT	H	7/16/46	BMT	H	105	7/17/46	BMT	H	0
20*	?	7/15/46	BMT	H	7/16/46	BMT	H	75	7/17/46	BMT	H	50
21*	?	7/15/46	BMT	H	7/16/46	BMT	H	205				
23*	?	8/5/46	BMT	30	8/6/46	BMT	30	70				
25	m	10/12/46	BMT	38	10/13/46	BMT	38	50				
26	f	10/12/46	BMT	38	10/13/46	BMT	38	75	10/14/46	BMT	38	26

* Juvenile. Abbreviations as in Table 1.

in the dryer burned thicket areas. I have never taken a rice rat in pine flatwoods or turkey oak, although Bangs (1898; 188) says in his discussion of *Oryzomys p. palustris:* "The rice-field mouse, while perhaps preferring fresh and salt-marshes as its abode, is by no means confined to such places. I have caught it in dry old fields, heavy swamps, and hummocks, and even on sand hills." He also states that *Oryzomys palustris natator* is often found in dry situations (Bangs, *op. cit.*; 189).

An analysis of the stomach contents of three rice rats taken in June, 1946, yielded a number of seeds of *Sesban emerus*, besides a quantity of undeterminable plant remains. The seeds were present in each stomach.

Of 19 marked individuals, six were retaken. The longest overnight distance, 270 feet, was recorded for an immature. Another immature traveled a minimum distance of 222 feet in one night. Other records on this species are given in Table 2. None of the marked animals were retaken in plant communities other than the one of original capture.

Sigmodon hispidus hispidus Say and Ord. Cotton rat.—Thirty-eight cotton rats, 15 males, 5 females, 17 unsexed immatures, and one undetermined, were taken in the Tiger Bay area. The immatures were taken in May, July, August, and October. A female was taken on July 2, 1946, and kept in captivity. When examined two days later she was found to have given birth to a litter of three. Their appearance bears out Audubon and Bachman's observations on the precocity of the young of this species (Audubon and Bachman; 231). They state that the young, usually from four to eight to a litter, begin to leave the nest within five or six days after birth. The young that I observed could not have been over a day and a half old, yet they were already clothed in brownish fur, the eyes were partially open and the ears were unfolded. A fine coat of white hair was present on the underparts. All were males. The average measurements for the litter of three, within 1½ days after birth, were 85 x 33 x 13 x 3 mm. The average weight was 7.17 grams. The measurements

TABLE 4.—*Occurrences of mammals in six ecologic communities*

SPECIES	PLANT COMMUNITY					
	S	MS	UMT	BMT	PW	TO
Didelphis virginiana pigra	X		X		X	
Cryptotis floridana				X	X	
Blarina brevicauda carolinensis		X	X			
Pipistrellus s. subflavus	X	X	X	X	X	
Lasiurus seminolus	X		X	X	X	
Procyon lotor elucus	X	X				
Mustela frenata peninsulae						X
Lutra canadensis vaga	X					
Sciurus c. carolinensis	X		X	X		
Sciurus n. niger					X	
Glaucomys volans querceti						X
Geomys tuza austrinus					X	X
Reithrodontomys h. humulis				X		
Peromyscus g. gossypinus	X		X	X	X	X
Peromyscus nuttalli aureolus					X	
Oryzomys palustris natator	X	X	X	X		
Sigmodon h. hispidus			X	X	X	
Sylvilagus palustris paludicola		X	X	X		

Abbreviations as in Table 1.

of the only surviving member of the litter on January 9, 1947, six months after birth, were 255 x 98 x 27 x 16 mm. The weight was 87.5 grams.

Unlike the actions of cotton mice, the young uttered no sounds while I examined and weighed them. The mother did not evidence the concern that female cotton mice show over their young. Ten days after birth the youngsters were replicas of the adult except for size. They were quite active and took full advantage of the exercise wheel in the cage, both during the day and at night. They ate roaches, spiders, grasshoppers, crackers, and laboratory chow.

The cotton rat is able to swim, but not as efficiently as the cotton mouse. An individual placed in a tub of water evidenced poor body coordination. The tail was not used for propulsion, as far as I could see, and the body tended to sink quickly, until only the tip of the nose remained above water.

Thirty-four cotton rats were marked; 12 were recaptured. The longest distance recorded was 205 feet. Data regarding these movements is given in Table 3. These animals were taken in greatest number in burned thicket. Data on the returns from marked cotton rats are in

accord with those of Erickson (1949) and Stickel and Stickel (1949). All suggest a rather limited range for this species, at least in comparison with the cotton mouse.

Sylvilagus palustris paludicola (Miller and Bangs). Swamp rabbit.—This animal has been seen several times in the marginal thicket and twice in the marshy swamp associations. Its trails are numerous in both places.

Domestic dogs and cats from nearby houses are the carnivorous mammals most in evidence in Tiger Bay. One house near the southeastern limits of the area supported a group of five or six dogs. These animals have been seen in the swamp, and cats have been observed hunting around the edges after dark. Other predators recorded here are the screech owl (*Otus asio floridanus*), barred owl (*Strix varia georgica*), bald eagle (*Heliaeetus l. leucocephalus*), and water moccasin (*Agkistrodon piscivorous*). Howell (1932; 296) states that remains of mice were found in the stomachs of four barred owls taken in the vicinity of Gainesville. Man's influence, through hunting and burning, is probably one of the main

TABLE 5.—*Comparative abundance of small mammals in six ecologic communities*

PLANT COMMUNITY	S	MS	UMT	BMT	FW	TO	TOTALS
Trapnights	942	495	1170	1302	825	850	5584
Peromyscus g. gossypinus	31		31	26	17	2	93
Oryzomys palustris natator	6	20	9	10			45
Sigmodon h. hispidus			16	19	3		38
Cryptotis floridana				4	3		7
Blarina brevicauda carolinensis		1	1				2
Reithrodontomys h. humulis			1				1
Peromyscus nuttalli aureolus					1		1

Abbreviations as in Table 1.

factors involved in influencing the equilibrium of the mammalian populations in the Tiger Bay area.

LITERATURE CITED

AUDUBON, J., AND J. BACHMAN. 1846. The viviparous quadrupeds of North America. 1: xv + 383.

BANGS, OUTRAM. 1898. The land mammals of peninsular Florida and the coast region of Georgia. Proc. Boston Soc. Nat. Hist., 28: 157–235.

BLAIR, W. FRANK. 1935. The mammals of a Florida hammock. Jour. Mamm., 16: 271–277.

——— 1941. Techniques for the study of mammal populations. Jour. Mamm., 22: 148–157.

COOKE, C. W. 1939. Scenery of Florida interpreted by a geologist. Fla. Geol. Surv. Bull., 17: 5–118.

ERICKSON, A. B. 1949. Summer populations and movements of the cotton rat and other rodents on the Savannah River refuge. Jour. Mamm., 30: 133–140.

HAMILTON, W. J., Jr. 1941. Notes on some mammals of Lee County, Florida. Amer. Midl. Nat., 25: 686–691.

HARPER, F. 1927. The mammals of the Okefinokee Swamp region of Georgia. Proc. Boston Soc. Nat. Hist., 38: 191–396.

HOWELL, A. H. 1932. Florida bird life. Fla. Dep't of Game and Freshwater Fish and the Bureau Biol. Surv., U. S. Dep't Agric., 1–579.

IVEY, R. DEWITT. 1947. The mammals, excluding bats, of Palm Valley, Florida. Master's thesis, Univ. Florida, 1–129.

MOORE, J. C. 1942. A survey of the mammals of the University of Florida conservation reserve. Master's thesis, Univ. Florida, 1–167.

——— 1946. Mammals from Welaka, Putnam County, Florida. Jour. Mamm., 27: 49–59.

Moore, J. C. 1949. Putnam County and other Florida mammal notes. Jour. Mamm., 30: 57–66.

Rand, A. L., and Per Host. 1942. Mammal notes from Highland County, Florida. Results of the Archbold Expeditions, no. 45, Bull. Amer. Mus. Nat. Hist., 80: 1–21.

Small, J. 1931. Ferns of Florida. Science Press. iii + 237.

——— 1933. Manual of the southeastern flora. Pub. by author, x–xxii, 1–1554.

Sherman, H. B. 1941. A box trap for the capture of live Geomys. Jour. Mamm., 22: 182–184.

Stickel, L. F., and W. H. Stickel. 1949. A *Sigmodon* and *Baiomys* population in ungrazed and unburned Texas prairie. Jour. Mamm., 30: 141–150.

West, E., and L. Arnold. 1946. The native trees of Florida. Univ. of Florida Press, 1–212.

Department of Biology, University of Florida, Gainesville, Florida. Received September 10, 1949.

WINTER FECUNDITY OF CAGED MALE WHITE-FOOTED MICE IN MICHIGAN

By Walter E. Howard

The white-footed mouse (*Peromyscus leucopus noveboracensis*) was not found breeding in nature in Michigan from November to March (Burt, 1940; Howard, 1949). The author handled about 125, that were field-caught, in the Laboratory of Vertebrate Biology of the University of Michigan, Ann Arbor, where this study was conducted. Of the hundreds of these mice reared in this laboratory from stocks collected throughout much of the geographic range of the species in the United States, some individuals were fecund during winter.

Cross-matings between *Peromyscus leucopus noveboracensis* and *P. gossypinus* (Table 1), which are fully cross-fertile (Dice, 1940), showed that only the females of the Michigan mice studied were sexually inactive during winter in the laboratory; males were fecund throughout the year. On January 16, 1947, twenty-eight mated females of *noveboracensis* were examined, and none was in breeding condition (pregnant, open vagina, or recent vaginal plug). Many of these females proved fertile during the following summer, but it was impossible to know whether all were fertile as many of the matings were broken and the individuals were used in other experiments. Cotton mice continued to breed, and 16 laboratory litters were produced during the winter by six of nineteen females. Nearly all of those that yielded no winter litters also failed to produce offspring the following summer.

Most of the cotton mice were laboratory descendents from a stock taken near Gainesville, Florida, during 1942; others were field-caught near Welaka, Florida, by W. F. Blair in March, 1946. The white-footed mice mostly were trapped by the author near Ann Arbor, Michigan, in August, 1946; others were taken by Van T. Harris in the same locality during October.

Male *Peromyscus* have been considered by some workers to be in breeding condition only when the testes are descended to the scrotal position. Close

examination of numerous males in different species, both in the field and laboratory, showed that many sired litters when the testes appeared abdominal, hence the criterion of descended testes may not be valid as an indicator of breeding condition. Descended testes in these species may be partly a response to increased environmental temperature.

The testes were scrotal in a *Peromyscus b. boylii*, field-caught on May 14, 1948, at the San Joaquin Experimental Range in California. The animal was placed in an old household refrigerator, where the temperature fluctuated between 28° and 51° F.; when removed the following morning the testes appeared abdominal. On the afternoon of the same day, however, the testes were again scrotal, and the animal was returned to the refrigerator. The testes were not scrotal when examined on the next two days, but after the animal was removed the testes again descended to the lower limit of the scrotum.

In male white-footed mice, and some other rodents, viable sperm, not external appearance of the reproductive organs, determines the fecundity of males.

TABLE 1.—*Litters from matings of Peromyscus leucopus and P. gossypinus produced in a Michigan laboratory between November 1, 1946, and March 1, 1947*

PARENTS	MATINGS	LITTERS	FERTILE FEMALES
♀ *leucopus* x ♂ *leucopus*	10	0	0
♀ *leucopus* x ♂ *gossypinus*	18	0	0
♀ *gossypinus* x ♂ *leucopus*	19	16	6
♀ *gossypinus* x ♂ *gossypinus*	19	12	8

In the study of the prairie vole (*Microtus ochrogaster*), Jameson (1947) found that abdominal testes do not indicate a non-breeding condition; many of his specimens with abdominal testes were fecund. Males were fecund when females were not. He concluded "that the females, not the males, limit the breeding season of this species." Miller (1946) investigated pocket gophers (*Thomomys bottae*) to determine the relation of size and position of the testes to breeding. During the heat of summer, the testes tended to be relatively small and scrotal, becoming relatively larger and more abdominal in winter. There was, however, no reliable relationship of either size or position of testes to breeding. In the wild brown rat (*Rattus norvegicus*) Perry (1944) found no evidence of seasonal variation in the breeding capacity of males, that seasonal variation in the breeding rate of the population as a whole must be governed solely by changes in the reproductive cycle of the female.

The geographic ranges of the two species of *Peromyscus* used in the experiment described above are known to overlap in eastern Virginia. Dice (1940) found them together in the same habitats, but discovered no evidence of hybridization. Where they occur together it is likely that females of the two species have similar breeding seasons, but some psychological or sexual isolating mechanism may be operative, as reported for other species of *Peromyscus* by Blair and Howard (1944).

Many factors probably interact to determine the breeding season in any locality for a particular species of *Peromyscus*. While not clearly understood, they probably involve the annual reproductive rhythm of glands such as the anterior pituitary (Moore, *et al.*, 1934), length of day (Baker, *et al.*, 1932, and Whitaker, 1940), temperature, and the quantity and quality of food (Bodenheimer and Sulman, 1946); the last named factor is related to day length, temperature, and the amount of moisture.

LITERATURE CITED

Baker, John R., and R. M. Ranson. 1932. Factors affecting the breeding of the field mouse (*Microtus agrestis*). Part 1.—Light. Royal Soc. London Proc., 110: 313–322.

Blair, W. Frank, and Walter E. Howard. 1944. Experimental evidence of sexual isolation between three forms of mice of the cenospecies *Peromyscus maniculatus*. Univ. Mich. Contrib. Lab. Vert. Biol., 26:1–19.

Bodenheimer, F. S., and F. Sulman. 1946. The estrous cycle of *Microtus guentheri* D. and A. and its ecological implications. Ecol., 27: 255–256.

Burt, William H. 1940 Territorial behavior and populations of some small mammals in southern Michigan. Univ. Mich. Mus. Zool., Misc. Publ., 45: 1–58, 2 pls., 8 figs., 2 maps.

Dice, Lee R. 1940. Relationships between the wood-mouse and the cotton-mouse in eastern Virginia. Jour. Mamm., 21: 14–23.

Howard, Walter E. 1949. Dispersal, amount of inbreeding, and longevity in a local population of prairie deermice on the George Reserve, southern Michigan. Univ. Mich. Contrib. Lab. Vert. Biol., 43: 1–50, 2 pls., 24 figs., 1 map.

Jameson, E. W., Jr. 1947. Natural history of the prairie vole (mammalian genus *Microtus*). Univ Kansas Mus. Nat. Hist., 1: 125–151, 4 figs.

Miller, Milton A. 1946. Reproductive rates and cycles in the pocket gopher. Jour. Mamm., 27: 335–358, 6 figs.

Moore, C. R., G. F. Simmons, L. J. Wells, M. Zalesky, and W. O. Nelson. 1934. On the control of reproductive activity in an annual-breeding mammal (*Citellus tridecemlineatus*). Anat. Record, 60: 279–289.

Perry, J. S. 1944. The reproduction of the wild brown rat (*Rattus norvegicus*). Proc. Zool. Soc., 115: 19–46.

Whitaker, W. L. 1940. Some effects of artificial illumination on reproduction in the white-footed mouse, *Peromyscus leucopus noveboracensis*. Jour. Exp. Zool., 83: 33–60.

Division of Zoology, University of California, Davis, California. Received July 26, 1949.

CROW PREDATION UPON NESTLING COTTONTAILS

By Charles M. Kirkpatrick

In 1933 the writer came upon some crows as they were attacking young rabbits in their nest. More than a decade later the experience was repeated in another state, vividly recalling the first episode. A partial survey of crow and cottontail literature revealed no reports of similar observations. The conclusion was that the two observations were but a fortuitous set of events since they occurred so far apart in distance and time. The predator-prey relationship between crows and nestling cottontails assumed greater significance recently when five similar cases were described casually in a family conversation. The author's brother was sufficiently impressed by witnessing three cases of predation within less than two weeks that he mentioned the experiences for their unusual nature. At this, the author's father added the details of two more cases which he remembered clearly. He also remarked that he had seen crows destroy cottontail nests a number of other times, but he could not remember dates and places accurately. The repetitious details of these dramas as they are described in the cases below leave little doubt as to the accuracy of the observations in each case.

A more extensive search brings to light an account in Barrows and Schwarz (1895) telling of a crow attacking and killing a young rabbit on a road. Trippensee (1934) writes that H. M. Wight examined a cottontail nest where crows had been feeding. He found dead and mutilated young. The exhaustive reports of Barrows and Schwarz, and of Kalmbach (1918), show that cottontail rabbits are eaten frequently by crows. The former noted the remains of rabbits in 38 of 909 crow stomachs examined with the majority occurring in May. Rabbits were not taken earlier than April or later than June, indicating that the availability of rabbits as crow food is related to the spring season. Later, Kalmbach reported on 2118 stomachs examined and stated, "Cottontail rabbits (*Sylvilagus* spp.), especially the young, were the rodents most frequently taken by crows, being found in 21 stomachs. . . In areas where cottontails are plentiful they form an important part of the food of nestling crows. . . This food habit appears to be universal, records coming from all parts of the country." Since the foregoing reports are in the main based upon laboratory work, the crow's method of securing rabbits as food, whether as live prey or carrion, is omitted save for the account in Barrows and Schwarz. In a life history study of the cottontail, Haugen (1942) took from a crow a freshly-killed juvenile rabbit which he judged had been a recent nestling.

Although studies on numerous cottontail nests failed to reveal any crow predation (Beule, 1940; Beule and Studholme, 1942), the evidence above strongly suggests that the crow is an important predator of the cottontail, particularly of the young which are easier to find and subdue. Trippensee (1934) stated that the large crow populations coincident with cottontail range is cause enough to regard crows in this light.

In the absence of any known, detailed records of crows destroying rabbit nests and preying upon the young, a series of eye-witness accounts are given below which add to the seasonal predator-prey relationship between these species. Al-

though the author has questioned a number of associates and students with no other cases being discovered, it is not improbable that many field men have had at least isolated experiences of this nature, descriptions of which yet repose in their field notes.

DETAILS OF PREDATION

Case 1.—Early spring, 1933. Decatur County, Indiana.

While driving along a country road I saw what appeared to be a fight involving two crows (*Corvus b. brachyrhynchos*) and a cottontail rabbit (*Sylvilagus floridanus mearnsii*). The car was stopped and it was seen that the crows were not attacking the cottontail, but something else on the ground, although the rabbit seemed intent on driving the crows away by rushing at them. With growing curiosity I left the car and ran toward the conflict taking place on the side of a low hill in a heavily grazed pasture. Upon my approach one of the crows seized a young cottontail which squealed as the crow flew away with it. The adult ran off a short distance into some blackberry (*Rubus* sp.) briar cover.

Where the action had taken place a cottontail nest was found in the sod with scarcely any concealing cover. The nesting materials had been torn from their depression, by the crows, as my later experience proved they would do. A second juvenile was found a few feet away, alive and apparently unharmed. It appeared too small to have left the nest of its own accord. The nest was reconstructed as well as possible and the young cottontail was replaced. No further observations were made at this nest.

Case 2.—Spring, 1938. Greensburg, Decatur County, Indiana.

During the fall of 1937 the weed cover of a vacant lot next to my home had been mowed and the matted residue left on the ground. Early one morning, about May 1, my father saw a crow walking about on the plant debris as though hunting for something. The bird flew away when my father came into its sight. Early in the morning of the next day two crows were seen at the same place in the lot, one of them feeding upon something. When approached the crows flew about 100 yards away. The spot where they had been seen was investigated and a rabbit nest was found torn apart. Several pieces of freshly torn skin of young rabbits were found about the destroyed nest. No live juveniles were seen nor was the adult rabbit around. (This could possibly be a case of scavenging.)

Case 3.—Spring, 1938. Decatur County, Indiana.

While driving along State Road 29 near Greensburg, my father saw two crows at a distance down the road. They were working vigorously in a side ditch apparently trying to catch something. As the car approached the crows, an old rabbit was seen in the ditch; this momentarily led my father to suspect that the crows were attacking the adult. However, as one crow flew away it carried a young rabbit in its bill. A cottontail nest was found in the sod of the ditch, but no young were in it. A few yards away a live nestling was found with skin torn severely from its neck and one side.

Case 4.—April, 1945. Fort Knox, Hardin County, Kentucky.

One morning in early April, before any foliage had appeared on the trees and when new grass had just emerged, I rounded the northwest corner of the Medical Research Laboratory. This part of the building faced toward a partly wooded ravine. A crow, within 20 to 30 yards and unaware of me, was busily working at something on the ground, under the edge of a small ornamental conifer which had been planted on a sodded slope. An adult rabbit was hopping nervously about several yards from the crow.

As I stood motionless close to the building, only a few seconds passed until I realized that for the second time I was observing the depredation of a rabbit's nest by a crow, and thereupon resolved to note all the details possible to see. The crow rapidly picked up grass and fur in its bill and tossed this nest material about at random as it searched the nest. Suddenly the crow made a few bouncing jumps which carried it several feet away from the nest from which a young rabbit apparently had been flushed. The crow caught the juvenile which began to squeal loudly. At this, the mother dashed up and made several spirited rushes

at the crow which did no more than jump a little sideways, meanwhile putting the young on the ground and pecking at it to subdue it. (I did not see the crow use its feet to hold its prey, which later proved to be of a size capable of leaving the nest.) At this point I ran up and gave a shout to see what the crow would do. It dropped the cottontail and flew into a low tree not more than 25 yards from me, showing no fear and apparently waiting for me to leave so it could finish its meal. The young rabbit was still alive and wet from being mauled on the grass, but not bloody or torn. I put it back into what was left of the nest and covered the nest with the debris so that the cavity and its contents were not visible.

When this was finished I was surprised to note that the crow had not flown, but seemed to be biding its time until I left. I threw a rock at the bird and it flew about 100 yards away and called several times. A few hours later in the same day I returned to the spot and found two crows on the ground in the vicinity of the nest. As I watched them for perhaps a minute they quartered the ground as if hunting more rabbits. They flew away together when approached. The rabbit nest was torn up again and the young one was not to be found. Although I watched this nest for several days, no more crows were seen around it.

Case 5.—April 1, 1949. Avon, Hendricks County, Indiana.

A rabbit nest was situated in weed stubble about 30 yards from the house of my brother, and within 20 feet of a mowed lawn. Therefore, it was an open situation with no ground cover. About 6:00 A.M., three crows were seen on the ground walking about from eight to ten feet apart. An old rabbit dashed frantically about the center of the group. When the crows were fired at with a 410 gauge shotgun they flew away, and the rabbit ran off a short distance, staying within sight. My brother examined the area and found the rabbit nest which had not been noticed until the crows had drawn attention to it. The nest, somewhat torn up, contained young with eyes shut. One nestling had skin peeled from top of head and neck. The nest was put back together and covered up.

The next morning the crows were back at the nest, but flew away at a shout. They soon returned to a distance of 30–40 yards. It was not possible to watch the crows' behavior any longer on this day. They were not noted again, but one week after the original episode only one rabbit was left in the nest.

Case 6.—April 7, 1949. Avon, Hendricks County, Indiana.

While driving along State Road 36, my brother noted three crows working at something in a closely grazed blue grass pasture. Virtually no cover was present. Within a sort of a triangle formed by the crows, an adult rabbit was hopping about. The spot the crows were interested in was roughed up as compared with the surrounding pasture. No close examination was made, but the activity of the crows plus the presence of the old rabbit were highly suggestive that the crows were ransacking a nest. Blowing the car horn did not disturb the crows which were about 30 yards from the road. This action was noted at noon.

Case 7.—April 10–12, 1949. Avon, Hendricks County, Indiana.

A field with a thin covering of old weed stocks lies west of my brother's house noted in Case 5. About 150 yards from the house, in this field, my brother observed three crows about 7:00 A.M. Through 6 x 30 binoculars he could see them jumping about on the ground, and finally saw one crow fly away with a small rabbit in its beak. The young cottontail was still alive since it squealed. An examination of the spot proved that the crows had plundered a rabbit nest. Nesting materials were scattered over an area about three feet in diameter. More than one nestling had been killed and partly eaten as indicated by fresh blood on the ground which was littered with ears, legs, and pieces of fur. One part of a small nose was found. Apparently the last young rabbit had been carried away since no others were found. No adult rabbit was seen.

CROW BEHAVIOR AT RABBIT NEST

The evidence is clear cut. Crows are capable of finding rabbit nests and they prey upon the nestling cottontails in the face of adversity and under conditions when the traditional crow wariness must be forsaken for boldness.

In each case noted above, the crows' behavior at the rabbit nests falls into a general pattern. When circumstances prevent the individual crows from duplicating the usual sequence of events, the gaps are easily interpolated from the actions of their fellows in similar situations. The observer first notices one or more crows busily engaged on the ground where ground cover usually is sparse to nonexistent. In some cases an adult rabbit is present either hopping about solicitously or making what appears to be offensive charges at the intruders. The action between mammal and bird draws attention and arouses curiosity at once in the observer, perhaps leading to the early conclusion that the crows are attacking the adult rabbit. In spite of the adult cottontail, the crows rifle the nest and capture young. Some of the prey are dispatched, dismembered, and probably swallowed on the spot. The bird possesses surprising presence of mind and tenacity of purpose in carrying away entire nestlings, either alive or dead, if frightened by the observer.

The crow, having found a nest and perhaps having tasted its contents, is difficult to discourage. An observer in a car is unnoticed (Cases 1, 6). When an observer on foot deliberately drives off the bird, it may not take flight, but remain close by, an observer itself (Cases 4, 5). Even a shotgun blast directed at the predators from a house immediately adjacent to the scene of depredation is soon forgotten or disregarded, for the same crows or, less probably, others return to the rabbit nest (Case 5).

In most cases, the predation takes place early in the morning although predation later in the day has been noted indicating that the crow locates the nest either by noticing the parent at the nest during the dawn feeding, or by the sound of the squealing young.

As many as three crows may attack the nest at one time indicating that more individuals are involved than a pair foraging for their own nestlings (Cases 2, 5, 6, 7). Upon some occasions, when a single crow is flushed from its work (Cases 2, 4), a pair later returns, presumably including the first individual noted.

PREDATION RELATED TO COVER

The tendency of crows to destroy rabbit nests and to prey upon the nestlings is related to nesting cover deficiencies as far as these cases are concerned. All predation occurred in spring and in situations where ground cover was low grade. Four cases were noted in suburban areas; two in heavily grazed pastures; and one in low grass of a well-kept roadside. When covering vegetation is at a minimum, the exposed nest site gives poor concealment to the adult and facilitates the crows' locating the nests as the adult visits them to care for the young. The chances of the depredation being noticed are also increased when cover is lacking.

Where a large series of cottontail nests were studied in Pennsylvania, it was found that a number of cover types were used although the nests occurred more frequently in open situations than in any other type (Buele, 1940; Beule and Studholme, 1942). Beule observed 91 nests from April to September with-

out encountering any nest destruction by bird predators. His suggestion that open sites chosen for litters may have survival value because less traveled by mammalian predators is substantiated by the data of Beule and Studholme for 121 nests. In roadside, fencerow, pasture, and fallow field situations, i.e., where cover might be less than optimum, they found that the number of successful nests ranged from 50 to 80 per cent. Various agents of destruction are listed for 49 nests, eleven of which were being observed, but predaceous birds were not included.

In Iowa, Hendrickson (1940) studied 51 nests from April to September and noted that 25 of them had been in cover less than six inches tall when used. Mortality of young or destruction of the nests was not assessed, but herbaceous cover not exceeding six inches would be no deterrent to crows.

Within limits, cover may not be the important factor in determining detection or concealment of a rabbit nest. Young rabbits may be heard squealing in the nest during the day (Hamilton 1940). Beule and Studholme (*op. cit.*) noted that the female often approached within a few feet in response to squeals of nestlings being handled. Trippensee (1934) cited other examples of maternal anxiety in the cottontail when the nestlings squealed upon being disturbed. Raptors apparently are attracted by the cries of distressed animals. Upon one occasion, the author was scrutinized closely by a great horned owl (*Bubo v. virginianus*) which had flown up from some distance in response to the squealing of a rabbit being taken from a live trap. Again when a fox squirrel (*Sciurus niger rufiventer*) squealed lustily in my hands a young Cooper's Hawk (*Accipter cooperii*) in head-long flight stopped only a few feet away. Therefore, it is not unlikely that curious and perhaps hungry crows having once been lured to a good meal by the sound of young rabbits may become proficient in this type of hunting, particularly at the season when other live prey is at a minimum and ground cover is favorable for predation.

SUMMARY

1. The destruction of cottontail rabbit nests by crows is given in seven eye-witness accounts. In five of the cases crows were observed preying upon the nestling rabbits.

2. The observations substantiate early literature on crow foods which show that cottontails are a common item of prey during the spring.

3. The behavior of the crows in the act of predation falls into a general pattern in which the typical crow wariness is modified or abandoned.

4. The predation, as noted, is related to the spring of the year and to poor nesting cover. The possibility of crows being attracted to the nests by the cries of the young rabbits is considered.

LITERATURE CITED

Barrows, W. B., and E. E. Schwarz. 1895. The common crow of the United States. U. S. Dept. Agri., Div. Ornithol. and Mamm., Bull. No. 6: 1–96.

Beule, John D. 1940. Cottontail nesting-study in Pennsylvania. Trans. N. A. Wildl. Conf. 5: 320–328.

Beule, John D., and Allan T. Studholme. 1942. Cottontail rabbit nests and nestlings. Journ. Wildl. Mgt., 6: 133–140.

Hamilton, W. J., Jr. 1940. Breeding habits of the cottontail rabbit in New York State. Journ. Mamm., 21: 8–11.

Haugen, Arnold O. 1942. Life history studies of the cottontail rabbit in southwestern Michigan. Amer. Mid. Nat., 28: 204–244.

Hendrickson, George O. 1940. Nesting cover used by Mearns cottontail. Trans. N. A. Wildl. Conf. 5: 328–331.

Kalmbach, E. R. 1918. The crow and its relation to man. U. S. Dept. Agri., Bull. No. 621: 1–92.

Trippensee, R. E. 1934. The biology and management of the cottontail rabbit, *Sylvilagus floridanus mearnsii* (Allen). Unpublished Ph.D. thesis, University of Michigan, Ann Arbor.

Agricultural Experiment Station, Purdue University, Lafayette, Indiana. Received, October 7, 1949.

BREEDING HABITS OF THE BOBCAT IN NORTHEASTERN UNITED STATES

By E. Michael Pollack

The bobcat (*Lynx rufus rufus* Schreber) is one of the common predatory animals in northeastern United States, yet little is known about its life history. This is due in part to the shy and secretive nature of the bobcat. The data presented are based on the macroscopic examination of the reproductive tracts of 33 female bobcats collected in Massachusetts and New Hampshire. Uterine measurements were recorded on 11 tracts and detailed measurements of the entire tract were made of 22 bobcats taken in different months of the year. Effort was made to collect all reproductive tracts of female cats killed from eary February to the end of the breeding season. As bobcat hunting and trapping usually ends by the first of April in the New England states, a complete year's series of female reproductive tracts could not be secured.

Breeding season.—Seton (1929) gives the breeding season for bobcat as late February or early March, with a gestation period of about 70 days. Grinnell, *et al.* (1937), in California, reports that C. C. Cummings recorded finding embryos in the following months: January, March, April, August, and September.

On May 10, 1947, Lloyd Viner, an experienced bobcat hunter of Rutland, Massachusetts, ran a female bobcat into a cave. He killed this cat and then heard a crying kitten which he captured. Upon returning to this cave the next morning, Viner found a dead kitten outside the cave. Both of the young cats, with unopened eyes, had umbilical cord remnants which were only partially dry. Greenleaf Chase, Saranac Lake, New York, reported that a trapper took a female bobcat on May 7, 1947, which contained two fetuses within a few days of birth. Both were well furred.

Duke (1949) made a microscopic examination of twelve female reproductive tracts of bobcats from southern California and northeastern New Mexico which were probably *Lynx rufus baileyi* and *Lynx rufus uinta*. He states that the

histology of the bobcat ovary resembles that of the domestic cat. The latter is "seasonally polyestrous." From the material he examined, however, a limited breeding season in the spring of the year is suggested for the bobcat. Mathews (1941) reports that the reproductive behavior of the wildcat (*Felis silvestris grampis* Miller) is apparently seasonally polyestrous. This cat has one period of heat in the first half of March, a second at the end of May and early in June, and another, rarely, in the fall. The only evidence that bobcats in the United States are "seasonally polyestrous" is the previously mentioned observations by C. C. Cummings.

Asdell (1946) states that in the order Felidae "Ovulation is induced by coitus and rarely occurs in its absence." Therefore, in the present study the ovaries of the reproductive tracts collected were examined and the number of corpora lutea were recorded. Corpora lutea of bobcats, like those of the white-tailed deer and some other mammals, persist longer than one breeding season. Duke reports finding corpora lutea in all ovaries regardless of the time of year trapped. He further grades corpora lutea according to pigmentation. The pale corpora lutea represent recent ones and the darker corpora lutea are the older of the ovulation cycle. Cheatum (1949), studying the reproductive behavior of the white-tailed deer in New York, found the corpora lutea to persist in a shrunken pigmented state throughout a second annual breeding season.

Concerning the relationship between the number of corpora lutea and embryos, Duke states the following: "It may be that at ovulation more ova are released than become viable embryos. All the resulting corpora lutea may then not be required to maintain the pregnancy, so some of them exhibit a different histological sequence." The number of corpora lutea in the series of tracts examined in the present instance varied, the highest being 14, which was slightly higher than what Duke found.

Turgid uteri usually denote the approach of estrous (Hamilton, 1939) or early pregnancy. The first evidence of turgidity occurred in a bobcat collected on March 1, 1949. That this suggests commencement of estrous is substantiated by the same condition in all the uterine horns collected after this date.

Although numerous small graafian follicles were found in all the tracts collected, regardless of the season, the first apparently mature graafian follicles were closely correlated with turgid uterine horns and light corpora lutea. A cat weighing 20 pounds, taken on March 12, 1949, had the largest graafian follicles recorded, these averaged 8.2 millimeters in diameter. This suggests that this female was coming into oestrous. A 13.3-pound cat killed on March 17, 1949, also showed three large graafian follicles. The position of the growing graafian follicles or site of graafian follicles seems to be related to the dark (older) rather than to the pale (recent) corpora lutea.

This series of tracts covers a time range greater than that of Duke's material yet offers no strict evidence on the point of delayed implantation which Duke considers a possibility.

Because relatively few specimens were collected after April 1, it was not possible to determine how long the breeding season lasts. Indirect evidence suggest-

ing that in exceptional cases bobcats in this region may breed quite late in the spring is offered by one instance of a kit taken late in the year and still retaining its lacteal dentition. This animal was collected on December 1, 1948, in Massachusetts.

Litter size and parental care.—Seton (1929) reported that the litter size varies from two to four, but generally is three in number. Grinnell, *et al.* (1937) reported that W. H. Parkson believed the average litter of California bobcats to be three. Interviews with hunters and trappers indicate that the average litter of bobcats in Massachusetts is two. Fred Scott, conservation officer at Pittsburg, New Hampshire, sent in, on January 6, 1949, a female bobcat weighing 16 pounds 4 ounces that was trapped with its presumed three young—two females and one male which weighed 10¼, 10½, and 10½ pounds. He stated that all four cats were taken within a radius of one-half mile.

A female cat weighing 13.3 pounds and its two young were killed on December 2, 1948, at Blandford, Massachusetts. To judge by the tracks, these three animals were living in a restricted area. The mother and one kit were killed one day and the other kit the following day. Lloyd Viner states that the young stay with the mother until January and then the litter breaks up. According to Hamilton (1943) the young leave the mother by fall.

Growth of young.—The smallest Massachusetts kitten, taken on December 15, 1948, weighed 5¼ pounds. However, since this kit had lost its lacteal dentition it was judged to be older than a kit taken on December 1, which still retained its milk teeth and weighed 10.5 pounds. A number of cats weighing seven pounds or under were collected after March 1. Although many were subadults, their physical condition was poor. There is probably a good deal of variation in weights, but the examples above are extremes and it is probable that the cat weighing 5¼ pounds was a stunted animal.

A recently born bobcat kitten taken by Lloyd Viner on May 10, 1947, was nursed by a domestic cat for 11 days before its eyes opened. A litter mate, found dead on the same date the live kitten was taken, weighed 12 ounces which may approximate the birth weight. Measurements of this cat after mounting are: total length, 252 mm.; tail, 26.4 mm.; right hind foot, 29.4 mm. This specimen had very sharp claws and was well spotted. The other young cat was kept captive for three or four months and possibly died from a heavy infestation of ectoparasites.

Examination of reproductive tracts give some indication of the age when female cats become sexually mature. The presence of two dark corpora lutea in the reproductive tract of a cat killed on November 27, 1948, showed that this animal had been bred. Since the weight of this cat was 12 lbs. 1 oz. it is evident that bobcats may breed when they reach the first spring. To further substantiate this fact, three young cats, killed on January 17, 1949, which averaged approximately 10½ pounds, might have attained the weight of the female described above. As additional evidence, the reproductive tract of an 11-pound female, although showing no corpora lutea when killed on February 10, did show many small growing graafian follicles which could be mature and ripe by the late

spring. On the other hand, the reproductive tract of a cat which weighed 5 lbs. 12 ozs. showed definite young graafian follicles of only pin head size. It is questionable that this cat, collected in mid-February, would have bred during the spring.

A female bobcat weighing 15 pounds was trapped on March 30, 1949, and kept captive until it died on May 17, 1949. Examination of the reproductive tract showed that the uterus was not turgid at this date.

Monogamy or polygamy.—Search of available literature provided no definite evidence as to whether bobcats are monogamous or polygamous. No information on this subject was obtained in the present study. The two instances cited above of mother bobcats accompanied by young, late in the year with no mature male present, suggests that the mother exercises parental care long after the male parent has left the family group.

Sex ratio.—Of the total carcasses and stomachs received, the known sex ratio of 180 specimens was 92 males and 88 females.

Acknowledgments.—This is a contribution of the Massachusetts Cooperative Wildlife Research Unit, supported by the Fish and Wildlife Service, the Massachusetts Division of Fisheries and Game, the University of Massachusetts, and the Wildlife Management Institute. Helpful advice was given by Dr. William G. Sheldon of the Fish and Wildlife Service, Professor W. J. Hamilton of Cornell University, and Professor Walter F. Greene of Springfield College. Much of the material was provided by the New Hampshire Fish and Game Department.

LITERATURE CITED

ASDELL, S. A. 1946. Patterns of mammalian reproduction. Comstock Publishing Company, Ithaca, New York.

CHEATUM, E. L. 1949. The use of corpora lutea for determining ovulation incidence and variations in the fertility of white-tailed deer. The Cornell Veterinarian, XXXIX, No. 3.

DUKE, K. L. 1949. Some notes on the histology of the ovary of the bobcat (lynx) with special reference to the corpora lutea. Anat. Rec., V. 103, no. 1, January.

GRINNELL, JOSEPH, JOSEPH S. DIXON, AND JEAN M. LINSDALE. 1937. Fur bearing mammals of California, Berkeley, Univ. of Calif. Press.

HAMILTON, W. J., JR. 1939. American mammals. McGraw-Hill Book Company, Inc., New York.

——— 1943. Mammals of eastern United States. Comstock Publishing Company, Ithaca, New York.

MATTHEWS, L. H. 1941. Reproduction in the Scottish Wildcat, *Felis silvestris grampia* Miller. Proc. Zool. Soc. London, Series B, 111: 59–77.

U. S. Fish and Wildlife Service, Oklahoma City, Oklahoma. *Received November 11, 1949.*

NOTES ON THE LIFE HISTORY AND ECOLOGY OF THE OPOSSUM IN SOUTHEAST IOWA

By George L. Wiseman and George O. Hendrickson

The research with the opossum (*Didelphis v. virginiana* Kerr) was done January to June, 1942, mostly on a 4-section area including and surrounding Stockport, Van Buren County, southeastern Iowa, and partly on 13 adjacent sections. War conditions terminated field work earlier than planned and opportunity was not afforded to analyze and organize the data until recently.

Although the land was for the most part under intensive cultivation, approximately 12 per cent was in pastured timber predominantly of the white oak type. Grassy and brushy fence rows and Osage orange hedge fence lines on the intensively cultivated portions of the area provided convenient travelways for animals during periods when crop lands were bare. Small partly wooded streams interspersed over the area, fed largely by agricultural drainage tile, attracted wildlife.

During 1939–1941 the average mean temperature at Stockport was 51.8°F., and the average annual precipitation was 34.33 inches at a Federal weather station located within the study area (Reed, 1939–1941).

Field techniques.—The majority of the data was obtained in an extensive program of live trapping with box-type traps set primarily for spotted skunks as reported on by Crabb (1948), whom the senior writer assisted. Opossums thus secured were ear-tagged, weighed, examined for young in pouches, and for general condition and extent of frost damage to ears and tails.

Scats were collected at the traps. The scats from penned opossums were found to have no characteristics which would serve to distinguish them positively from those of predators such as the fox, dog, and cat. Only six scats of the opossum were discovered in the open, although a trail of urine was noted for a few feet along an opossum trail in the snow several times.

A total of 64 box traps was constantly in operation during the investigation. One section of land was trapped at a time, with a trap allotted geographically to each 10-acre quadrat in the section. The traps were moved at three-week intervals in such manner that 32 traps occupied 320 acres of a central portion at all times. The remaining 32 traps were rotated, and were adjacent to the 32 traps in the central part. The bordering areas trapped included the 0.5 sections along the sides of the central section and the 0.25 sections at the corners. This gave coverage of the bordering area each three weeks and twice as much coverage of the central part. The traps in each 10-acre quadrat were placed at the spot thought most likely to produce a catch. To further enhance the possibility of catches, the traps were moved to other likely locations within the quadrat each week.

The traps were dipped in muddy water before setting, and in placement they were blended as well as possible with the surroundings. Fresh bait was placed in the traps once each week or oftener. During the winter rabbit meat was the principal bait. As the weather warmed, canned fish, rotten eggs, and mulberries

were used successfully. A lure was used in combination with the bait. This lure was generally a spotted skunk lure since this species was the major object of the research program. Anise oil, which is considered a good opossum lure by professional trappers, was used also. Trapping success did not indicate that it was more attractive than the spotted skunk lure to opossums.

Care was taken to clinch the metal fingerling tags securely without pinching the ear between the parallel sections of the tag after attachment. The thin bare ears of the opossum are subject to damage by cold in severe weather. Because frosting sometimes results in the sloughing off of the edges, the tags were attached at the base of the ear close to the head to lessen possible loss.

In most instances the opossums were sufficiently docile to allow holding with bare hands. Occasionally, an individual required much caution to prevent biting the handler. After blocking the head against a wall of the box trap with a stick, an unruly individual was grasped firmly behind the head with no damage to the handler. Most of the individuals excreted a small amount of scented liquid which soiled the hair around the anus.

Denning.—Opossums on the area were observed to den chiefly in ground burrows made by other animals, notably the woodchuck. Of 23 dens known to have been used by opossums on the area eight were in ground burrows; five in straw stacks; three in junk heaps; two under chicken houses; one under a small storage shed; one under a garage; one in the hay of an unused barn; one under the floor of an unused cowshed; and one in a low hollow of a large fenceline cottonwood tree. In no case did a den expose the opossum to direct light. During periods of cold weather ground and straw stack dens were used the most.

Range and mobility.—Two individuals, tracked in light snow over the entire courses of a night's travel, returned to the dens from which they had commenced their night's foray. One individual covered a zigzag route of about one-half mile through a bare field and pasture. The second covered a distance of approximately one and one-fourth miles before returning to his den under a shed. The temperature was at 20°–25° F. during the nights that these trails were made. The trails of three other individuals, followed over the entire courses of a night's journey, ended at dens other than those from which the animals had started. One animal covered a distance of approximately two miles in a haphazard manner. The other two opossums each covered a distance of approximately one and one-half miles during the night.

The limited range and mobility of the opossum are indicated by recaptures. Three opossums tagged by Wilfred Crabb during the summer, 1941, while live-trapping spotted skunks on the area, were recaught in 1942. One was recaught on the 10-acre quadrat adjoining that in which it was captured the previous year. Another was recaptured within the 10-acre quadrat where she was tagged in 1941. The third was taken one-fourth mile from her original place of capture. Four females, tagged in 1942, were recaptured less than one-half mile from the original points of capture. A male opossum tagged February 16, 1942, was recaught only one-half mile away on April 2. Nineteen other opossums tagged in 1942 were not recaptured. The 24 captures, and indicated mobility and range

of recaptures, suggest a population density of about six opossums to a section. The trails of some individuals in snow passed within three or four feet of freshly baited traps, when only corn was readily available for food in the fields. Whether this behavior represented individuals previously caught, and hence trap shy, or a natural tendency, is questionable. Possibly such behavior explains the relatively small proportion of recatches.

Cold weather tolerance.—Below a temperature of 20°F. the outdoor movement of opossums was practically negligible as indicated by lack of fresh snow tracks. In no instance was sign observed that indicated the opossum had been out when the temperature was 10°F. or lower. On two occasions, when night temperatures were 20°F., tracks from ground dens made a circle of a few feet and returned. Visits to the dens of opossums in current use when the temperature was 0°–15°F. revealed no signs of activity. Damage to the ears and tails of the animals was observed frequently. Of the adult opossums handled, one-third had sustained damage to ears. Recent damage left the ears raw. When healed, the edges of the ears were fringed with scar tissue and the ears were sometimes shortened considerably. The tails of several individuals were shortened—to as little as two inches on one.

In forages when snow was on the ground the opossums usually followed a more or less haphazard route, with little zigzagging indicative of hunting for small mammals. Although in travels they used the grassy fence rows and hedges largely, occasionally the animals struck out across fields and pastures. In winter, signs of feeding on corn in the field and of digging for insects were observed. In some instances a large portion of an ear of corn was taken at a feeding. Old hay-stack butts were frequently visited for insects.

Breeding activity.—Observation indicated the first part of February as the earliest date for breeding of opossums in southeastern Iowa. The first female with young was captured on February 23. At that time the young were determined to be no more than two days old. Considering the 12–13-day gestation period, a mating date of near February 10 was indicated (Hartman, 1928; McGrady, 1938). This female and the young were kept in captivity, and the growth rates of the young were recorded in detail to form a basis for the determination of the ages of subsequent litters. Other females, later observed with young, had borne their litters at approximately the same date and into early March. Reynolds (1945) determined the breeding season in central Missouri to commence February 1. In southeastern Iowa the breeding season appears to start a week to ten days later.

Three females taken in May had pouches moist within, enlarged teats, and swollen mammae; no young were in their pouches. Two of these females were in a very weakened condition when taken from the trap. One walked a few steps and died after release. Another, taken for observation when her weakened condition was noted, died within a few hours. The third individual was taken in for observation because of her condition. After the aforementioned mother of the young, kept for growth data, escaped and left her young behind, the young, nearly three months old, were placed with the newly captured female held for

observation. Although penned for a week, and her pouch was drying inside, she adopted the young, seemed to produce an ample supply of milk, and lay quietly on her back while they nursed.

At the age of 60 days the young were barely able to walk when removed from the teats. Five days later the eyes had opened and the mouth slits, which had previously been only oral suckers, became free at the sides, allowing the mouths to open. At the age of 67 days the young were observed outside the pouch of their own accord for the first time. From then on they became progressively more efficient at getting about by themselves. At the age of 75 days they were observed to eat solid food, raw meat, for the first time. Two days earlier, milk-soaked bread and raw meat offered to them stimulated attention and licking the lips, but no eating. At the age of 90 days the young foraged rather well for themselves and weighed eight ounces each.

Data concerning the number of litters produced yearly by a female are not sufficiently complete to make conclusive statements. Young opossums two days old were observed with a female on June 6, and young two weeks old were observed with a female on June 12. Although it is not known that these were second litters of the year, this possibility seems plausible. Females bearing young in late February could have their young weaned and be mated again by June 1, or earlier. It seems very unlikely that a third litter is produced in Iowa. Young of a third litter could hardly weigh as much as a pound by December 1, and trappers did not relate taking such small individuals. Individuals weighing a little more than a pound are sometimes taken during open trapping season, starting about November 10–15, but these are almost certainly second litters born later than June 1. The seven litters varied from a maximum of 12 to a minimum of six; the average, nine.

Food habits.—Of 87 scats analyzed, 39 were collected January–March, 1942, the winter period, and 48 scats April–June, 1942, considered the spring period. Small groups of scat particles were considered as a separate specimen, and fecal material trampled in the trap was considered as one scat. Remnants of food items were recorded by frequency and percentage of frequency occurrence (Table 1).

During the winter, corn appeared to form the bulk of the opossum's diet, and many scats consisted almost entirely of corn refuse. As the season advanced into spring the proportion of insect remnants increased until they made up a large part of some scats. Mulberries, ripened late in May, were taken freely, replacing corn no longer readily available in the fields. Crayfish appeared in March and increased in the diet as spring came along. Mammal refuse, appearing very irregularly in the scats, indicated carrion, very probably. A greater amount of corn and less of other major food groups in the diet of Iowa opossums than in that of Missouri opossums is indicated on comparison with Reynolds' (1945) findings. This may be explained by the greater availability of corn on the Iowa areas.

A few chicken and small bird feathers were recorded in the analysis. As no cases of poultry killing on the area during the period of the investigation could

TABLE 1.—*Number of occurrences of food item remnants in 39 winter scats and 48 spring scats of opossum in southeast Iowa, January–June, 1942, with their percentage frequency of occurrence in parentheses*

FOOD ITEMS	WINTER (39 SCATS)	SPRING (48 SCATS)	TOTAL (87 SCATS)
INSECTS	32 (82)	44 (92)	76 (87)
Orthoptera			
Grasshoppers (Locustidae)	12 (31)	1 (2)	13 (15)
Crickets (Gryllidae)	0	1 (2)	1 (1)
Cockroaches (Blattidae)	1 (3)	0	1 (1)
Hemiptera			
Stink bugs (Pentatomidae)	2 (5)	0	2 (2)
Coleoptera			
Ground beetles (Carabidae)	23 (59)	41 (85)	64 (73)
Carrion beetles (Silphidae)	0	1 (2)	1 (1)
May beetles (Scarabidae)	0	5 (10)	5 (6)
Darkling beetles (Tenebrionidae)	1 (3)	1 (2)	2 (2)
Skin beetles (Trogidae)	0	4 (8)	4 (5)
Unidentified insects	6 (15)	5 (10)	11 (13)
OTHER ARTHROPODS	6 (5)	23 (48)	29 (38)
Millipedes (Diplopoda)	2 (5)	9 (19)	11 (13)
Crayfish (*Cambarus*)	4 (10)	17 (35)	21 (24)
REPTILES		1 (1)	1 (1)
Unidentified snake scales	0	1 (2)	1 (1)
BIRDS AND EGGS	3 (7)	4 (8)	7 (8)
Domestic chicken (*Gallus gallus*)	3 (8)	1 (2)	4 (5)
Unidentified small bird	0	2 (4)	2 (2)
Eggs, meadowlark (*Sturnella magna*)	0	1 (2)	1 (1)
MAMMALS	6 (15)	13 (27)	19 (22)
Shrew (*Microsorex*)	0	3 (6)	3 (3)
Meadow vole (*Microtus*)	1 (3)	6 (13)	7 (8)
White-footed mouse (*Peromyscus*)	2 (5)	1 (2)	3 (3)
Cottontail (*Sylvilagus floridanus mearnsii*)	3 (8)	3 (6)	6 (7)
Unidentified hair	0	2 (4)	2 (2)
CULTIVATED GRAIN AND PLANT ITEMS	36 (92)	21 (44)	57 (66)
Corn (*Zea mays*)	33 (85)	13 (27)	46 (53)
Cottonwood buds (*Populus deltoides*)	0	2 (4)	2 (2)
Cottonwood leaves	1 (3)	0	1 (1)
Miscellaneous seeds	7 (18)	6 (13)	13 (15)
Grasses	2 (5)	2 (4)	4 (5)
FRUITS	10 (26)	17 (35)	27 (31)
Mulberry (*Morus*)	2 (5)	16 (33)	18 (21)
Ground cherry (*Physalis*)	7 (18)	1 (2)	8 (9)
Grape (*Viitis*)	1 (3)	0	1 (1)

be attributed to the opossum, this material very probably was taken as carrion. In a farmer survey on the 17-section study area it was learned that frequently opossums were destroyed on sight and especially when they appeared at the farmsteads. In only one instance was a farmer able to relate positively of an opossum molesting poultry. At dusk one spring evening he heard squawks of a

hen, and discovered a large opossum making off with a hen in its mouth. The hen was not injured as she was able to run off on release. During the research period one opossum, taken alive in a hen house by a poultry owner, was given to the writer. Scats of this opossum showed a few chicken feathers. As no chickens had been preyed upon in the vicinity, it is believed the feathers were ingested with chicken feed.

Summary.—From January to June, 1942, twenty-four opossums, ten males and fourteen females, were caught in box type traps incidental to spotted skunk trapping in Van Buren County, southeast Iowa. They were ear-tagged, weighed, and examined.

Five males averaged 6 pounds 13 ounces in weight; ten adult females, 4 pounds 1 ounce. Young opossums caught in late May and early June weighed 8–12 ounces each.

Of the twenty-three observed opossum-used dens, eight were in woodchuck and other mammal ground burrows, five in strawstacks, three in junk heaps, one in hay of an unused barn, five under small farm buildings, and one in a hollow of a cottonwood tree. None was exposed to direct sunlight.

The trails of two animals returned to the dens from which a night's travel (one-half mile and one and one-fourth miles, respectively) started. The trails of three other individuals ended at other dens than those from which they started, after two had travelled one and one-half miles each, and a third two miles.

No opossum activity was noted outside opossum dens at temperatures below 0°F.

One-third of adult opossums had frost-damaged ears; several had frost-shortened tails, as short as two inches.

Recaptures, in 1942, of three opossums tagged in 1941 indicated a yearly mobility of one-fourth mile; four tagged in 1942 were recaptured within one-half mile from sites of tagging.

The earliest indicated date of breeding was about February 10, and the latest about June 4, as determined from weight and size measurements of young. Very probably not more than two broods were borne by a female in the season. Seven litters averaged nine young, with extremes of six and twelve.

In a penned litter at 60 days, young were barely able to walk when removed from the pouch; at 65 days the mouths were widened and could be opened; at 67 days the young were outside the mother's pouch, of their own accord; at 75 days they ate food, raw meat, for the first time; at 90 days, and individual weights of 8 ounces, they foraged well for themselves.

Of 87 scats analyzed for food remnants, 81 were obtained at the traps and only six were found in the open, despite much time in search. During winter months, corn, the bulk of the diet, was supplemented by insects (chiefly grasshoppers and ground beetles), small mammal and chicken carrion and refuse, and wild fruit. In spring, corn decrease in the diet was made up with increases in insects, especially beetles, and crayfish, small mammal carrion, and wild fruits.

Opossums were frequently killed on sight to protect domestic poultry despite no known recent depredation, according to a farmer survey.

LITERATURE CITED

CRABB, W. D. 1948. The ecology and management of the prairie spotted skunk in Iowa. Ecol. Monog., 18: 201–232.

HARTMANN, C. G. 1928. The breeding season of the opossum (*Didelphis virginiana*) and the rate of intra-uterine and postnatal development. Jour. Morph. and Physiol., 46 (1):143–215.

McGRADY, E., JR. 1938. The embryology of the opossum. Amer. Anat. Mem., No. 16, 233 pp.

REED, C. D. 1939–1941. Monthly report, U.S.D.A. Weather Bureau, Ia., Sect. 50:1–124; 51:1–126; 52:1–124.

REYNOLDS, H. C. 1945. Some aspects of the life history and ecology of the opossum in central Missouri. Jour. Mamm., 26:361–379.

Department of Zoology and Entomology, Iowa State College, Ames, Iowa. Received January 21, 1950.

RODENTS AND INSECTIVORES FROM SELANGOR, MALAYA[1]

BY JOHN L. HARRISON AND ROBERT TRAUB

In the course of investigation into the ecology of scrub typhus (tsutsugamushi disease) in Malaya, a large number of mammals, chiefly rodents, have been collected in and near the town of Kuala Lumpur. Because of the potential significance of some of these mammals in the epidemiology of scrub typhus, a preliminary survey of rodents and insectivores collected during 1948 seems pertinent. Notes on habits and habitats are included where possible because so little is known about the bionomics of much of the fauna.

The senior author is serving as zoologist with the Scrub Typhus Research Unit, British Colonial Medical Research Service, centered at the Institute for Medical Research, Kuala Lumpur, Federation of Malaya. The junior author served as Major, MSC, with the U. S. Army Scrub Typhus Research Unit, on temporary duty from the Army Medical Department Research and Graduate School, Army Medical Center, Washington, D. C., on a project in part financed by the Commission on Immunization, Army Epidemiological Board. Thanks are due Dr. J. R. Audy of the Scrub Typhus Research Unit and Dr. R. L. Lewthwaite, formerly Director of the Institute of Medical Research, for many helpful suggestions. Grateful acknowledgment is made of the co-operation of Mr. Ben Insoll of the Selangor Museum, and of Mr. Lim Boo-Liat of the British Scrub Typhus Research Unit, both of whom helped collect mammals and amass data.

COLLECTING GROUNDS

Kuala Lumpur, the capital of the Federation of Malaya, is in the state of Selangor (3°N., 102°E.). It lies on the lowlands which stretch to the Straits of Malacca in the west and which are bounded to the east by forest-covered mountains and to the north by a spur of these same mountains. The lowlands are devoted largely to tin mines and to plantations of rubber and oil palm.

[1] Published under the auspices of The Surgeon General, United States Army, who does not necessarily assume responsibility for the professional opinions expressed by the authors.

Collecting has been carried out in terrain of five kinds:

Forest.—The lower slopes of the aforementioned spur to the north of the town are clothed with forest and inhabited by aboriginal pygmies referred to as "Sakai." Trapping has been carried out by ourselves and by the Sakai around their clearings and in the forest at an altitude of between 1000 and 2000 feet. In fact, "forest" represents vegetation of three kinds: (1) Primary forest, i.e. undisturbed rain forest. (2) Secondary forest or "blukar," the result of shifting cultivation and of lumbering. (3) Sakai gardens, in which are grown cassava ("tapioca"), sweet potato, and wet padi (rice).

Three forest areas have been trapped: along the Pahang road in the Ulu Gombak Forest Reserve, at various points from Gombak to Genting Sempak; at Kepong, in the Bukit Lagong Forest Reserve near the Forest Research Station at Kepong village; and at Bukit Lanjan to the south of Kepong, adjoining the Sungei Buloh Forest Reserve. The latter two localities seem to be included in the "Sungei Buloh" of Gater (1932) and of Kloss (1931).

Mountain forest.—A short visit was made to the Cameron Highlands, a hill station in the state of Pahang, on the same mountain chain as that which flanks Kuala Lumpur, but some 100 miles farther north. A small collection was made in forest at elevations of about 5000 and 6000 feet on Gunong Brinchang, but not enough to give a full picture of the fauna.

Town.—Rats are regularly trapped as part of the Kuala Lumpur town rat control scheme.

Waste land.—Of particular interest in the epidemiology of scrub typhus are the edges of country settlements, and land which had been cleared of forest or plantation by the Japanese for food cultivation, and subsequently abandoned or only partly cultivated. Such land becomes covered with a strong growth of the tall grass, "lalang" (*Imperata cylindrica*), and weeds.

Oil palm estate.—Trapping for rats has been carried out on some oil palm estates by estate laborers. Most of this collecting has been done in the estate mentioned by Lewthwaite (1930) and Gater (1932).

TRAPPING METHODS

Most of the animals were trapped in cage traps of wire mesh with a spring door. A few "Sherman" traps and wooden box traps also proved of value for obtaining such small species as *Rattus whiteheadi*, and *Chiropodomys*. Traps were placed on the ground or tied on to tree branches. For bait in forest, most fruits and vegetables were successful, and regularly used were bananas, jackfruit seeds, coconut meat (both fresh and toasted), cassava, sweet potato, and bamboo shoots, but above all, durian seeds. Durians are remarkably attractive to animals of all kinds, and even tigers have smashed our traps, apparently in an endeavor to reach the durian bait. This applies, however, only to localities in which durians are indigenous: in the Cameron Highlands, where this tree does not grow, durian as a bait failed conspicuously. In the town, dried fish, bread, vegetables, and balls of boiled rice were all successful as baits.

OCCURRENCE AND DISTRIBUTION OF SPECIES

Chasen (1940) has published a complete list of the mammals recorded from Malaysia. Tables 1 and 2 list the species recorded from the mainland of the Malay Peninsula with details on the frequency as found by us. Table 1 lists the tree-dwelling species and Table 2 the species primarily found on the ground, a division made necessary because the intensity of collecting of ground or tree

TABLE 1.—*Habitats of Malayan tree-dwelling rodents and insectivores*

SPECIES	FOREST	MOUNTAIN FOREST	KUALA LUMPUR TOWN	WASTE-LAND (SCRUB)	OIL PALM ESTATE
Sciuridae					
Callosciurus (Tamiops) maclellandi (Horsfield)	×	×	–	–	–
Callosciurus tenuis (Horsfield)	19%	××	–	–	–
Callosciurus lowi (Thomas)	××	–	–	–	–
Callosciurus erythraeus (Pallas)	–	×	–	–	×
Callosciurus caniceps (Gray)	8%	–	××	×	–
Callosciurus prevosti (Desmarest)	–	–	–	–	×
Callosciurus nigrovittatus (Horsfield)	16%	–	–	–	–
Callosciurus notatus (Boddaert)	12%	××	××	××	–
Callosciurus hippurus (Geoffroy)	×	–	–	–	–
Dremomys rufigenis (Blanford)	–	×	–	–	–
Ratufa bicolor (Sparrman)	××	–	–	–	–
Ratufa affinis (Raffles)	×	–	–	–	–
Muridae					
Hapalomys longicaudatus Blyth	–	–	–	–	–
Chiropodomys gliroides (Blyth)	23%	–	–	–	–
Pithecheir melanurus parvus Kloss	–	–	–	–	–
Rattus canus malaisia Kloss	××				
Rattus cremoriventer (Miller)	××	×	–	–	–
Tupaiidae					
Tupaia glis (Diard)	××	–	–	–	–
Tupaia minor Günther	××	–	–	–	–
Ptilocercus lowi Gray	–	–	–	–	–
Galeopteridae					
Galeopterus variegatus (Audebert)	×	–	–	–	–
Total number of specimens	357	9	8	3	2

× = seen; ×× = seen in number; – = not seen; % = proportion of all specimens seen.

species varies in different places and at different times. Since only two specimens of flying squirrel have been obtained out of the nine species recorded, this group is omitted altogether.

Species which occurred only once or twice are denoted by an ×; species which occurred regularly in small numbers or which although only trapped once or twice were seen more often, by two ×s; and those which formed a measurable element of the population by a percentage representing the proportion which they formed of all specimens collected in that zone.

Forest is characterized by a large number of species, no one of which is specially abundant. The apparent abundance of *Chiropodomys gliroides* is probably due to our special interest in collecting this species, heretofore considered rare.

TABLE 2.—*Habitats of Malayan ground-dwelling rodents and insectivores*

SPECIES	FOREST	MOUNTAIN FOREST	KUALA LUMPUR TOWN	WASTE-LAND (SCRUB)	OIL PALM ESTATE
Sciuridae					
Lariscus insignis (Cuvier)	8%	–	–	–	–
Rhinosciurus laticaudatus (Müller & Schlegel)	××	–	–	–	–
Rhizomyidae					
Rhizomys pruinosus Blyth		–	–	–	–
Rhizomys sumatrensis (Raffles)	××	–	–	–	–
Muridae					
Rattus rattus diardi (Jentink)	×		84%	19%	××
Rattus rattus argentiventer (Robinson & Kloss)	×	–	–	59%	–
Rattus rattus jalorensis (Bonhote)	7%	–	–	××	93%
Rattus exulans concolor (Blyth)	7%		××	14%	××
Rattus norvegicus (Berkenhout)	–	–	–	–	–
Rattus annandalei (Bonhote)	–	–	–	–	–
Rattus mülleri (Jentink)	18%	–	–	–	–
Rattus bowersi (Anderson)	××	–	–	–	–
Rattus niveiventer (Hodgson)	–	–	–	–	–
Rattus fulvescens (Gray)	–	××	–	–	–
Rattus whiteheadi (Thomas)	××	–	–	××	–
Rattus alticola inas (Bonhote)	–	××	–	–	–
Rattus rajah group	18%	–	–	×	–
Rattus edwardsi (Thomas)	14%	–	–	–	–
Rattus sabanus (Thomas)	××	–	–	–	–
Mus musculus L.	–	–	××	××	–
Bandicota bengalensis (Gray & Hardwicke)	–	–	–	–	–
Hystricidae					
Trichys lipura Günther	–	–	–	–	–
Atherurus macrourus (L.)	××	–	–	–	–
Hystrix brachyurus L.	–	–	–	–	–
Erinaceidae					
Echinosorex gymnurus (Raffles)	××	–	–	–	–
Hylomys suillus Müller	–	×	–	–	–
Soricidae					
Crocidura spp.	×	–	–	–	–
Suncus murinus (L.)	–	–	14%	××	–
Suncus malayanus (Kloss)	–	–	–	–	–
Total number of specimens	215	10	3427	252	432

× = seen; ×× = seen in number; – = not seen; % = proportion of all specimens seen.

Further, the ease of collection, once its particular habitat was noted, led to an unusually large number being taken. There is an element of town rats (*Rattus rattus diardi*, *Rattus exulans*) which is associated with the Sakai dwellings and gardens.

Mountain forest is not properly represented. An outbreak of banditry has prevented further collecting here. The results are included because even such a small collection shows clearly that the species assemblage differs from that of the lowland forest.

Town is clearly dominated by "domestic" species; *Rattus rattus diardi*, which is probably the local form of the cosmopolitan "shiprat;" *Suncus murinus*, the house shrew; and, in smaller numbers, *Rattus exulans*, the Burmese house rat, and *Mus musculus*, the cosmopolitan house mouse.

Waste land is dominated by another form of *Rattus rattus*, namely *R. r. argentiventer*. This form, or its representative, seems to be a widespread pest of cultivation in Malaysia. The town species also are present in some numbers associated with the scattered human habitations, and there is a sprinkling of forest species.

Oil palm is dominated by yet another form of *Rattus rattus*, this time *R. r. jalorensis*, a form which occurs quite regularly in forest and which probably is native there. The small proportion of *Rattus rattus diardi* and *Rattus exulans* appearing in Table 2 is from the laborers' quarters. The absence of squirrels is due to lack of collecting.

This collection, therefore, gives a very clear hint as to the changes which are going on in Malaya. The cutting down of the forest means banishment for most of the forest animals; a few survive in altered conditions (e.g. *Rattus whiteheadi* and *Rattus rajah* in wasteland), or adapt themselves and increase greatly (e.g. *Rattus rattus jalorensis* in oil palm). Most of the inhabitants of the new conditions are of imported species such as *Rattus rattus diardi*, which probably represents the cosmopolitan forms; *Rattus rattus argentiventer*, which probably came from elsewhere in Malaysia; *Rattus exulans*, which is associated with man from Burma to the Hawaiian Islands; *Suncus murinus*, which is similarly associated with man throughout southern and eastern Asia; and indeed the grass, *Imperata*, which is distributed throughout the Old World tropics.

NOMENCLATURE AND HABITS

Although Chasen (1940) is the authority for the list of species recorded from Malaya, in names, we have followed without criticism Ellerman's FAMILIES AND GENERA OF LIVING RODENTS (1940 and 1942), as modified by him in 1947. With the exception of the three forms of *Rattus rattus*, we have not attempted to differentiate the "subspecies" where several occur.

Chasen gives "English Names" to most of the animals, but, as we have not met anyone who uses such names, we have omitted them. Wherever possible, we have given the name by which the animal seems to be known to our Sakai collectors. The Sakai, who comprise many different tribes (with as many languages), seem to distinguish by name most of the different species. All but one of our collectors are of the Wong tribe. They speak to us in Malay, and many of the names are Malay, some are Sakai, and some a mixture of Sakai and Malay. In spelling these names we have followed the Royal Geographical Society system in which, broadly speaking, vowels are pronounced as in Italian and

consonants as in English. An apostrophe (') is used to indicate a glottal stop and an italic *e* the neutral vowel. Most names in the list involve the Malay word for squirrel, "tupai," or rat, "tikus."

We have included notes on the habits of the animals; many of these are reported by the Sakai, and such remarks are qualified by "said to."

ACCOUNTS OF SPECIES

Callosciurus (Tamiops) maclellandi (Horsfield). One specimen was obtained from Mountain Forest in the Cameron Highlands, and one by a Sakai who had been a long journey, probably into mountains. It is said to nest in tree holes.

Callosciurus tenuis (Horsfield). "cholis" or "chole."—This small tree squirrel is the most frequent in forest and mountain forest, but it is not seen far away from forest. It is said to build its nests of leaves in the axils of tree branches and leaves of palms, and it feeds on fruits. Seventy specimens from Pahang Road, Kepong, and Bukit Lanjan, have been examined.

Callosciurus lowi (Thomas). "chong."—This rather uncommon forest squirrel is said to frequent the ground as much as trees, to build its nest among bushes or tree roots, and to feed on fruits. Four specimens were trapped at Pahang Road.

Callosciurus erythraeus (Pallas). Two specimens were taken in mountain forest, where it was observed to build a nest of leaves high in trees.

Callosciurus caniceps (Gray). "tarata."—This squirrel is very common in secondary forest and in association with man. It builds nests in trees and feeds on fruit. Thirty-seven specimens were examined from the three forest sites.

Callosciurus prevosti (Desmarest). "tupai blan."—Here, this squirrel seems confined to plantations; none have been seen in forest. It is said to nest in trees and feed on coconut and rubber seeds, to which probably should be added oil palm fruit. Two specimens collected.

Callosciurus nigrovittatus (Horsfield). "tupai ke-ol."—Although abundant in forest and secondary forest, this species does not seem to occur outside. It is said to nest in trees and to feed on fruits. Fifty-seven specimens were collected at Pahang Road, Kepong, and Bukit Lanjan.

Callosciurus notatus (Boddaert). "tupai mera."—This is the best known squirrel in Malaya because it frequents gardens. It is also abundant in forest and in mountain forest. It nests in trees and feeds on fruits. Thirty specimens were collected in the three forest sites.

Callosciurus hippurus (Geoffroy). "tupai chin-chang."—Despite intensive hunting only one specimen has been collected, and that at Pahang Road. It is said to live high in the tree canopy.

Dremomys rufigenis (Blanford). Two specimens were obtained from mountain forest.

Ratufa bicolor (Sparrman). "tupai mangas."—This giant squirrel is quite abundant in forest, but is confined to very high trees where it is usually out of reach. It is said to build a large nest high in the trees and to feed on fruit, occasionally raiding orchards. Four specimens taken at Pahang Road.

Ratufa affinis (Raffles). "tupai puchok" or "tupai pute."—Notes as for the preceding species. Two specimens from Pahang Road.

Lariscus insignis (Cuvier). "chong tuin."—This species was fairly abundant at Pahang Road where sixteen specimens were taken in July and August, but it was not taken during the wetter months which followed. A specimen has been taken at Kepong. It is said to nest either in trees or on the ground among tree roots, and to feed on fruit.

Rhinosciurus laticaudatus (Müller & Schlegel). We are uncertain of the local name except that it is some combination of "chong," which seems to be a generic term for the ground dwelling squirrels.

It is undoubtedly a ground squirrel, and is possibly insectivorous. The Sakai state that it "lives on the ground like a rat," but opinions differ as to whether it burrows. They say that it feeds on fruit, but Robinson and Kloss (1909) state that the stomachs of specimens examined by them were full of insect remains. The stomachs of our four specimens (from Pahang Road) were unfortunately not examined.

Rhizomys sumatrensis (Raffles). "dekan."—This bamboo rat is probably fairly frequent among bamboo thickets in forest, but it is considered such good eating that most specimens caught go to the pot rather than to the museum. It is said to live in burrows in the bamboo thickets and to eat bamboo shoots. In captivity, a specimen refused all other food offered except sweet potato. It was never observed to drink from the water bowl, but would lick the wet edge of the bowl or wet cotton wool. Two specimens came from Pahang Road.

Chiropodomys gliroides (Blyth). "tikus kending."—This interesting and "rare" tree mouse was captured more frequently than anything else at Pahang Road, once its habitat was ascertained. *Chiropodomys* lives in bamboos and nests inside the stem. The nest is made of leaves arranged at the bottom of an internodal cavity and the exit hole is made near the top of this or a nearby internode. Holes through the nodes join a series of internodes into the long tunnel.

The six mammae are inguinal, and a mother with young was observed to run and to climb rapidly with the young holding fast to the nipples. The animal seems to be gregarious and in cages as many as possible will happily crowd together into a huddled mass. An adult, particularly a nursing mother, will chatter its teeth at intruders, other rats and humans alike. It is said to feed on fruit, but in captivity it is omnivorous. Eighty-one specimens from Pahang Road and Kepong were examined.

Rattus canus malaisia Kloss. "tikus legong."—This is the first time to our knowledge that this rat has been seen since Kloss (1931) and Gater (1932) reported it. It occurs only in forest where it is said to build nests in trees "like a bird." It eats soft fruit, and for a long time our captive specimens would eat nothing but banana, but they were eventually persuaded to eat sweet potato. Twenty-three specimens have been taken from the three forest sites.

Rattus bowersi (Anderson) [= *Rattus ferreocanus* (Miller)]. "tikus geru."—This is a ground rat which is said to live in burrows and to be omnivorous; captive specimens certainly eat anything, including meat. It occurs only in forest. Our most interesting observation is that specimens freshly caught in forest are so tame that they can be readily handled; they like to be tickled behind the angle of the jaw. Other forest species, such as *Rattus edwardsi*, are fairly tame on capture, in marked contrast to such house and garden species as *Rattus rattus diardi*, *Rattus rattus argentiventer*, and *Callosciurus notatus*. We have seen twelve *Rattus bowersi*, taken at Pahang Road and Kepong.

Rattus rattus (L.). This cosmopolitan species exists here in the following three forms, distinct both anatomically and ecologically: *Rattus rattus diardi* (Jentink)—This is a brown-bellied form which is closely associated with man and which appears to be close to the cosmopolitan ship-rat. It is the principal pest in towns, where it lives in houses. It is never found far from man's dwellings, specimens recorded from "forest" in fact came from burrows in Sakai gardens, and specimens from "oil palm" from near the laborers' quarters. Nearly 3000 specimens were examined in the course of the investigations. *Rattus rattus argentiventer* (Robinson & Kloss) is a large grayish-backed form with a silvery-gray venter. It is rare in forest, and the Sakai here call it by the same name as *Rattus mülleri* and ascribe the same habits to it. We take this as evidence that it is a chance intruder into the forest edge. It is the common pest of rice fields, and is found by us to be the dominant form in lalang-covered waste land. One hundred and fifty-three specimens were studied. *Rattus rattus jalorensis* (Bonhote), a small white-bellied form, appears to be truly native, although we have been unable to sort out a definite local name for it. It is to be found in forest where it is said to nest in burrows, and to be a general feeder. In oil palm estates it appears to be the dominant, in fact the only, rat living in the palms and feeding on the palm fruit. Four hundred twenty-five rats were examined.

Rattus exulans concolor (Blyth). Following Ellerman (1947), we have included the well-known *Rattus concolor* in the widespread commensal species, *Rattus exulans*. It is closely associated with man, but seems to prefer more rural conditions than does *Rattus rattus diardi*, and although it is one of the two rats to occur in the town area, it forms a larger proportion of the rats taken adjacent to squatters' huts in waste land, in Sakai gardens, and near the laborers' quarters in oil palm. One hundred and four were taken.

Rattus mülleri (Jentink) [= *Rattus validus* (Miller)]. "tikus aye."—This is a common rat in forest. It is said to live in burrows or rock holes near water (its local name means "water rat") and to feed on molluscs and crabs, as well as any available fruit and seeds. The Sakai seem to distinguish another form which lives in trees, but we can find no morphological distinction. Thirty-eight specimens were examined from Pahang Road, Kepong, and Bukit Lanjan.

Rattus fulvescens (Gray) [= *Rattus rapit cameroni* Chasen]. Five specimens of this subspecies, described by Chasen (1940), were collected at the type locality, mountain forest at Cameron Highlands.

Rattus cremoriventer (Miller). "tikus gu'o."—Sixteen specimens of this rare rat were taken by us in forest at Pahang Road, Kepong, and Gunong Brinchang in the Cameron Highlands. It is a tree rat and is said to build a nest of leaves and twigs among the branches, and to feed on fruit.

Rattus whiteheadi (Thomas). This appears to be one of the species, represented in primary forest, which do very well in secondary forest and which extend to waste land. It is not as well represented in our collection as it should be, probably because most of our traps are not well suited to such a small animal and no special effort has been made to collect it. It is terrestrial and a general feeder. It is said by some to burrow, but others say that it makes a nest of leaves on the surface of the ground. Sixteen specimens were taken, primarily from the three forest sites.

Rattus alticola inas (Bonhote). Five specimens were taken in mountain forest.

Rattus rajah (Thomas) group [including *Rattus pellax* (Miller), *Rattus surifer* (Miller), and *Rattus surifer leonis* (Robinson & Kloss)]. "tikus jang."—The members of this group are usually classified in three subspecies of two species, but they are not at all easy to distinguish, if indeed they are different. They live in burrows, in forest, secondary forest, and occasionally waste land, and are general feeders. Forty specimens were examined from the three forest areas.

Rattus edwardsi (Thomas). Thirty-one specimens were taken in the three forest sites. See comment for next species.

Rattus sabanus (Thomas). "tikus pera."—This species is closely related to the above; both are known by one and the same name to the Sakai, and seem to be of similar habits. Both live in forest in fairly extensive burrows, and are said to feed on fruits and to raid the Sakai's root crops.

Mus musculus (L.). The cosmopolitan house mouse is found only in and near houses, in which it does not seem to be as abundant as in temperate climates. Nineteen specimens were taken.

Atherurus macrourus (L.). "landak batu."—Fairly common in the higher land of the forest, this hystricid is said to nest in holes in the rocks and to feed on fruit.

Tupaia glis (Diard). "chong ulam."—Although insectivores, this treeshrew and the next seem to be almost entirely frugivorous, and to have a special liking for bananas. This species is said to nest in tree holes and sometimes among rubbish on the ground. It is found everywhere in forest. Fourteen specimens were collected at Pahang Road, Kepong, and Bukit Lanjan.

Tupaia minor Günther. "chong kue."—This species seems to prefer higher ground than does *glis*. Thirteen specimens from Pahang Road and Kepong were taken.

Echinosorex gymnurus (Raffles). "tikus kukus."—The "moon rat" seems not uncommon in deep forest. It is said to nest in rock holes or decaying logs and to feed on fruit. Three specimens were caught at Pahang Road.

Hylomys suillus Müller. One specimen of this rare animal was obtained from Cameron Highlands.

Crocidura spp. "tikus sula."—Although five species of this genus are recorded from Malaya, we have not yet had the good fortune to see much of them. Two specimens caught have not yet been identified.

Suncus murinus (L.) [= *Suncus caeruleus* (Kerr)]. This wide-spread house shrew is confined to houses or their immediate neighborhood. Although primarily insectivorous it seems to be a fairly general feeder. Four hundred and ninety-three specimens have been taken.

Galeopterus variegatus (Audebert). "kubong."—The so-called "Flying Lemur," on close inspection, looks much more like a flying ungulate, and indeed one of the Malay names for it is the equivalent of "the flying mouse deer." It is confined to forest, and our one specimen came from Bukit Lanjan, but it is not so rare as a single specimen would suggest. It is said to nest in holes in trees and to be a general vegetable feeder; the stomach of this specimen, as of those recorded by Robinson and Kloss (1909), was full of the remains of leaves.

Along with the mammals discussed above, Table 1 and Table 2 also list species not seen by us, but which are recorded for the Malay Peninsula. *Rattus norvegicus* (Berkenhout), for example, has not been taken by us, and has not been seen inland. It occurs in large numbers in ports, as in Singapore and Port Swettenham. *Bandicota bengalensis* (Gray and Hardwicke) has long been known from the island of Penang and is reported to be a new pest of rice fields in the northwestern state of Kedah. The two porcupines which we have as yet not collected, *Hystrix brachyura* L. and *Trichys lipura* Günther, are known to the Sakai as "chankas" and as "landak raya," and are stated to frequent the banks of streams.

SUMMARY

Investigations into the ecology of scrub typhus are involving the examination of a large number of small mammals, particularly rodents and insectivores, which are being trapped in forest, plantations, waste land, and town, in the state of Selangor, Federation of Malaya.

An account of the distribution of rodents and insectivores trapped during 1948 is given. Forest contains many species of similar abundance, town is dominated by *Rattus rattus diardi* and *Suncus murinus*, waste land is dominated by *Rattus rattus argentiventer* with both town and forest species present, oil palm estate is dominated by *Rattus rattus jalorensis*.

Notes on the habits of the species concerned are given. These species comprise all of the fourteen species of sciurids (but no flying squirrels) recorded from Malaya, one of the two Rhizomyidae (bamboo rats), fourteen of the twenty Muridae, one of three Hystricidae, and seven of the thirteen Insectivora.

Tabular data are presented showing the ecological distribution of Malayan insectivores and rodents.

REFERENCES

Chasen, F. N. 1940. A handlist of Malaysian mammals. Bull. Raffles Museum, Singapore, No. *15*.

Ellerman, J. 1940 & 1941. The families and genera of living rodents. London, British Museum (Natural History), vols. I & II.

Ellerman, J. 1947. Notes on some Asiatic rodents in the British Museum. Proc. Zool. Soc. London, 117: 259–71.

Gater, B. A. R. 1932. Malayan trombidiid larvae. Pt. I. Parasitology, London, 24: 143–74.

KLOSS, C. B. 1916. On two rodents new to the fauna of the Malay Peninsula with description of a new subspecies. Jour. Federated Malay States Mus., Singapore, 6: 249–52.

KLOSS, C. B. 1931. A new subspecies of Malaysian rat. Bull. Raffles Mus. Singapore, No. 5: 105–07.

LEWTHWAITE, R. 1930. Clinical and epidemiological observations on tropical typhus in the Federated Malay States. Bull. Inst. Med. Res., Federated Malay States, Kuala Lumpur, No. 1, 1930.

ROBINSON, H. C., AND C. B. KLOSS. 1909. Collectors notes. In Thomas & Wroughton, On Mammals from the Rhio Archipelago and the Malay Peninsula collected by Messrs. H. C. Robinson and C. Boden Kloss and E. Seimund and presented to the national museum by the government of the Federated Malay States, with notes by the collectors, Jour. Federated Malay States Mus., Singapore, 4: 99–129.

TATE, G. H. H. 1947. Mammals of Eastern Asia. The MacMillan Co., New York.

Department of Parasitology, Army Medical Department Research and Graduate School.
Received July 29, 1949.

GENERAL NOTES

A NEW RACE OF BADGER (*TAXIDAE*) FROM EASTERN KANSAS

After examining additional badger specimens from Kansas I have concluded that a new race exists in the eastern part of the state. I wish to acknowledge with thanks the courtesy extended to me by Dr. E. Raymond Hall, Museum of Natural History, University of Kansas, for the loan of specimens indicated in the following description. This new race is described as follows:

Taxidea taxus kansensis, subsp. nov.

Type.—No. 21989, Kansas University Museum of Natural History collection; adult female; skin and skull; from 4 miles southeast of McLouth, Leavenworth County, Kansas, November 30, 1947; collected by Henry Murr, and prepared by James O. Lonnquist. Original number 46.

Distribution.—Eastern Kansas, east of 97° longitude.

Diagnostic characters.—Large buffy badger with long white median dorsal stripe extending from near tip of nose to middle of back, or to rump, on all available hides.

Color.—Type: Winter pelage. Facial area, including eyes, forehead (except median line), and cheek patches, black as usual in this species; white median line extends from near the tip of the nose to the rump; white markings under and behind the eyes confluent with light buffy underparts of throat and neck; general dorsal area exclusive of white median line is a mixture of black, cartridge buff, and gray, with the cartridge buff and black predominating; dorsally the hairs are greystone basally, followed by cartridge buff, with a subapical black band tipped with gray, while on the sides the longer guard hairs are basally light buff, followed by buff, then a wide black band, with a subapical buff band and a longer gray tip; anterior part of, and median spot on, chin dark brown; general abdominal area light buff and black, hairs with the light buff predominating, becoming white along a narrow median line; ears blackish edged with white, fore and hind legs black, upper side of tail darker cartridge buff base, subapical black band, tipped with gray, tip of tail missing, underside of tail predominately dark cartridge buff. (Colors from DICTIONARY OF COLOR, by Maerz and Paul, 1930.)

Two specimens from Greenwood County, Kansas, were grayer, excepting that the one taken in April near Neal shows fresh pelage over a small dorsal area, which is more buffy than the rest of the late winter fur.

Skull.—The skulls compare closely with those of *T. t. iowae*, and average larger than those of *T. t. merriami*.

Measurements.—Type: Total length, 719 mm.; tail vertebrae, 111; hind foot, 102; condylobasal length, 125; zygomatic breadth, 78.4; mastoidal breadth, 75.4; interorbital breadth, 26.5; postorbital breadth, 27.5; palatal constriction, 13.8; palatilar length, 63.1; maxillary tooth row (alveoli), 40; crown length PM^4, 10.6; crown width PM^4, 9.6; crown length M^1, 12.8; crown width M^1, 10.5.

Skin measurements of an adult male: Total length, 765 mm.; tail vertebrae, 130; hind foot, 200 (?). Two adult females, respectively, total length, 710, 720; tail vertebrae, 120, 155; hind foot, 104, 113.

Cranial measurements, in millimeters, of two adult males: Condylobasal length, 128, 129.4; zygomatic breadth of one (latter), 86.8; mastoidal breadth of one (latter), 81; interorbital breadth (former), 27.7; palatal constriction, 15.8, 16; palatilar length, 62, 65.5; maxillary tooth row (alveoli), 41.5, 44; crown length PM^4, 10.7, 11.3; crown width PM^4, 10.1, 11; crown length M^1, 13.2, 14; crown width M^1, 10.6, 11.5.

Average and extreme cranial measurements of 4 females: Condylobasal length, 120.7 (117–125); zygomatic breadth, 75.9 (74.3–78.4); mastoidal breadth, 73.2 (71.7–75.4); interorbital breadth, 26.9 (24.8–28.8); postorbital constriction, 27.3 (25.6–29.2); palatal constriction, 14.1 (13.7–14.5); palatilar length, 60.8 (58.4–63.1); maxillary tooth row (alveoli), 40.5 (40–41.7); crown length PM^4, 11 (10.6–11.4); crown width PM^4, 10 (9.6–10.6); crown length M^1, 13.6 (12.8–14); crown width M^1, 11 (10.5–11.6).

Weight.—The weight of an adult male taken at Perry, Jefferson County, Kansas, is 21.6 pounds.

Remarks.—Taxidea taxus kansensis is a race of badger with a long white median dorsal stripe extending from near the tip of the nose to the middle of the back or to the rump. In this respect it shows intergradation with *berlandieri* to the southwest, but it is larger and lighter colored dorsally and in this regard shows integradation with *iowae* to the north and east of *kansensis*. Specimens from Greenwood County appear somewhat grayer excepting for new pelage appearing on the Neal specimen.

Specimens.—Total number 8, as follows: **Kansas:** Bern, Nemaha County, 1 (skeleton only, Kansas Univ.); Lawrence, Douglas County, 1 (skin and skull, Kansas Univ.); Manhattan, Riley County, 2 (skulls only); McLouth, Leavenworth County, 1 (skin and skull, type locality, Kansas Univ.); Neal, Greenwood County, 1 (skin and skull, Kansas Univ.); Perry, Jefferson County, 1 (skull and baculum, Kansas Univ.); Toronto (8 mi. S.W.), Greenwood County, 1 (skin and skull, Kansas Univ.).—Viola S. Schantz, *U. S. Fish and Wildlife Service, Washington, D. C.* *Received January 12, 1950.*

A NEW CHIPMUNK (*TAMIAS*) FROM ONTARIO AND QUEBEC

The distribution of *Tamias striatus griseus* Mearns, as given by Howell (N. Amer. Fauna, No. 52: 20–21), extends in a semicircular band from west-central Indiana northwest through Illinois and Minnesota to western Ontario thence east to the Gulf of St. Lawrence. Such an improbable distribution pattern suggested the existence of an undescribed northern race. Accordingly, a critical study was made of chipmunks from eastern Canada, including recently acquired material from Lake St. John and Lake Mistassini, Quebec.

The study disclosed that the chipmunks of central Quebec and central Ontario, heretofore referred to *T. s. griseus*, differ from that race consistently in size, coloration, and skull characters, and therefore deserve subspecific recognition. This new race may be known as:

Tamias striatus quebecensis, subsp. nov.

Type.—Adult female, skin and skull: National Museum of Canada No. 18987; St. Felicien, Lake St. John County, Quebec; June 7, 1946; P. A. Orkin; collector's number 046-2.

Distribution.—In Quebec, Moisie Bay, north shore of the Gulf of St. Lawrence, Lake St. John, and Lake Mistassini west to Kapuskasing, Ontario; intergrading with *lysteri* in southern Quebec and northeast of Lake Superior, and with *griseus* in southwestern Ontario.

Characters and comparisons.—Similar to *Tamias striatus griseus* Mearns, but averaging smaller and darker; grey of dorsal region darker and lacking the buffy admixture of that form; rump much darker and richer; white dorsal stripes not extending to base of tail; top of head darker and facial stripes more clearly defined; superciliary line distinct; dorsal aspect of tail darker with less buffy admixture and more broadly tipped with white; ventral aspect of tail averaging darker; sides averaging a deeper ochraceous-tawny. *Skull:* similar to *T. s. griseus*, but proportionately smaller, maxillary tooth row actually and relatively shorter, infraorbital foramen larger.

The present form differs so markedly in coloration from *T. s. lysteri* that a detailed comparison is unnecessary. The warm buffy tones of the latter race are almost entirely lacking in *quebecensis* in which the greys are darker and clearer, contrasting sharply with the reddish-brown of the rump.

Color of Type.—Similar to topotypes of *T. s. griseus*, but dorsal stripes Neutral Grey; rump Burnt Sienna tending towards a Mahogany Red; top of head and facial stripes between Russet and Hazel; sides of rump Ochraceous-Tawny shading into Buckthorn Brown on sides of body to Clay Color behind forelegs; reddish-brown edgings to black dorsal stripes Burnt Sienna. (Capitalized terms are from Robert Ridgway's "Color Standards and Color Nomenclature.")

Measurements.—Average of four adult females from the type locality: total length, 253.7 (249–264); tail vertebrae, 96 (91–106); hind foot, 35.8 (35–36). *Skull:* Average of four adults from Lake St. John, Quebec: Condylo-basal length, 33.8 (32.6–34.5); occipito-nasal length, 39.1 (37.4–40); zygomatic breadth, 21.4 (21–22); interorbital breadth, 10.2 (9.9–10.8); palatal length, 17.9 (17.5–18.2); length of nasals, 13.4 (12.5–14.3); alveolar length of maxillary tooth row, 6.5 (6.1–6.8).

Acknowledgments.—I am grateful to Dr. Remington Kellogg, United States National Museum, for the loan of Minnesota specimens, and to W. Earl Godfrey, National Museum of Canada, for examining Minnesota specimens in the Cleveland Museum of Natural History.

Remarks.—The Quebec chipmunk is a well-marked subspecies as shown by comparison with typical specimens of *T. s. griseus* and *T. s. lysteri*. The warm, buffy tones of *T. s. lysteri* are replaced in *T. s. quebecensis* by grizzled grey and dark, rusty browns. Although closer to *T. s. griseus*, the Quebec form is smaller and darker and lacks the buffy admixture on the dorsum of that form.

Chipmunks from central Quebec (Moisie Bay, Lake Mistassini, Waswanipi Post) and central Ontario (Kapuskasing) are *T. s. quebecensis*. This form intergrades with *T. s. lysteri* in southern and eastern Quebec (Gaspé County, Percé, Labelle County) and in southwestern Ontario (Pancake Bay), and with *T. s. griseus* north and west of Lake Superior (Thunder Bay District, Schreiber). Manitoba specimens (Shoal Lake, Dauphin) are referable to *T. s. griseus* although showing a tendency towards *quebecensis*.

Specimens Examined.—The following specimens were examined in the present study: *Tamias striatus quebecensis:* **Quebec:** Lake St. John, 9; Moisie Bay, 1; Lake Mistassini, 2; Waswanipi Post, 1; Perce, Gaspé County, 2; Lacoste, 20; Ste. Veronique, 10; Trout Lake, Labelle County, 7; Kamika Lake, 2; Lake Pourri, 3; Meach Lake, 3; Hatley, 3; Burbidge, 2; Oxford Mountain, 1; Lake Bernard, 1; Parker, 2; Sandy Creek, 1. **Ontario:** Kapuskasing, 5; Pancake Bay, 10; Thunder Bay District, 2; Schreiber, 4; Ridout, 3. *Tamias striatus griseus:* **Minnesota:** Fort Snelling, 10. **Manitoba:** Dauphin, 3; Shoal Lake, 1. *Tamias striatus lysteri:* **Ontario:** Ottawa, 23; Peel County, Lorne Park, 3; Point Pelee, 3; Guelph, 2; Preston, 4; Welland County, Central Proton, 3; Clayton, 3; Algonquin Park, 6. **New Brunswick:** Bathurst, 15; St. Andrews, 4; St. Leonard, 2; Edmundston, 1; Baker Lake, 2; Perth, 1.—Austin W. Cameron, *National Museum of Canada, Ottawa, Canada.* *Received February 21, 1950.*

THE TAXONOMIC STATUS OF *GEOMYS BREVICEPS TEXENSIS* MERRIAM AND *GEOMYS BURSARIUS LLANENSIS* BAILEY

The type localities of *Geomys breviceps texensis* Merriam (Mason, Mason County, Texas) and *Geomys bursarius llanensis* Bailey (Llano, Llano County, Texas) are approximately 33

miles apart. These two pocket gophers occur in an isolated area in central Texas where the soils are principally fine, sandy loams and are surrounded by other soils less suitable to pocket gophers. From the standpoint of the soils, this area, according to Carter (Texas Agri. Exp. Sta., Prog. Rep. 522 [mimeo.]: 6, 1938), is called the Central Basin and consists of some 2,000,000 acres including parts of Burnet, Llano, Mason, Blanco, San Saba, and Gillespie counties. This Central Basin, in general, is several hundred feet lower in elevation than the surrounding terrain and is deeply cut by the waterways of the Llano, Perdernales, and Colorado rivers. To date, these two pocket gophers have been considered as distinct species although Davis (Jour. Mamm., 19: 488, 1948) remarks that "the close similarity and overlapping of most cranial and external characters strongly suggests that their differences are of the nature currently recognized as distinguishing subspecies." In the past, specimens of these two pocket gophers have been reported only from or near their respective type localities. Specimens from several localities in the Central Basin, including places approximately midway between the two type localities, recently have been obtained by W. Kimball Clark for the Museum of Natural History of the University of Kansas.

Previous workers, including Bailey (North Amer. Fauna 25: 129, 1905) and Davis (*loc. cit.*), found cranial characters, but no external characters, by which these two kinds of pocket gopher could be distinguished. From *llanensis*, Davis (*loc. cit.*) was able to distinguish *texensis* by its shorter nasals, by its larger and more inflated bullae, and by its slightly narrower rostrum. In examining the new material as well as that previously reported on by Davis (Texas Agri. Exp. Sta. Bull. 590: 20, 32, 1940), I noted the distinguishing cranial characters described by Davis and, in addition, was impressed with the smaller and narrower size of the skull of males of *texensis* as compared with those of males of *llanensis*. Furthermore, the superior edge of the lateroventral face of the zygomatic arch is usually straight in males of *texensis* and is usually dorsally convex in males of *llanensis*; the reverse condition obtains in the females. The length of the dorsolateral exposure of the jugal, which has been mentioned as a character distinguishing *Geomys breviceps* from three other species including *Geomys lutescens* [= *Geomys bursarius*] by Davis (*op. cit.*: 5), appears not to apply since considerable variation is observable even in specimens from or near the type localities of *texensis* and *llanensis*. Pocket gophers taken at Castell, Llano County, and at ½ mile W Castell, Mason County—localities which are approximately midway between the type localities of *texensis* (Mason) and *llanensis* (Llano)—are intermediate in respect to these cranial characters. This evidence of intergradation is the basis for here arranging the two kinds as subspecies of one species. Further evidence of intergradation is the varying combination of characters to be seen in specimens from southwest and southeast of Llano. Therefore, until such time as the taxonomic relationship of *breviceps* to *bursarius* is established, the name *Geomys bursarius texensis* is applied to the population of pocket gophers with type locality at Mason, and the name *Geomys bursarius llanensis* is applied to the population of pocket gophers with type locality at Llano. Evidently the Llano River is not an effective barrier to the pocket gopher as indicated by this study.

Specimens examined.—*Geomys bursarius llanensis* Bailey (Total number, 50), San Saba County: 1 mi. N Pontotoc, 5; Llano County: Llano, 7; 3 mi. E Llano, 9 (6 in Texas Coop. Res. coll.); 7 mi. E Llano, 10 (Texas Coop. Res. coll.); Castell, 3; 3 mi. W and 1 mi. N Kingsland, 7; 12 mi. S and 8 mi. W Llano (Enchanted Rock), 9. *Geomys bursarius texensis* Merriam (Total number, 40), Mason County: 10 mi. W Mason, 6; 1 mi. W Mason, 2; Mason, 2 (1 in Texas Coop. Res. coll.); 1 mi. E Mason, 9 (Texas Coop. Res. coll.); 1 mi. SE Mason, 18; ½ mi. W Castell, 2; 11 mi. SW Mason, 1.—Rollin H. Baker, *Museum of Natural History, University of Kansas, Lawrence, Kansas. Received November 12, 1949.*

ON THE MIGRATION OF THE RED BAT, *LASIURUS BOREALIS BOREALIS*

An interesting observation on the migration of the red bat, *Lasiurus borealis borealis*, was made by Captain I. Mesmaekers of the Steamship Mahenge. Captain Mesmaekers reported his observation to Dr. James P. Chapin, and at Dr. Chapin's suggestion the captain forwarded specimens of the bats and an explanatory letter to the American Museum of Natural History. The letter contained the following information.

At daybreak, on the morning of September 29, 1949, a large number of bats, estimated at about 200, was seen flying about the ship. The position of the vessel was 40°10′ north and 71°00′ west, about 65 miles offshore. The weather was overcast with some rain and the wind was west-northwest at 20 miles per hour. Some of the bats remained on board searching dark places up to the time the ship reached the port of New York. Three of the bats were captured and two were placed in alcohol. The two bats preserved in alcohol are now in the collection of the American Museum of Natural History and bear the numbers 134985 and 134986.—T. Donald Carter. *American Museum of Natural History. Received October 17, 1949.*

NOTES ON BANDED BATS

Welter and Sollberger (Jour. Mamm., 20: 77–81, 1939) reported the banding of 2000 individuals of *Myotis sodalis* and *Myotis lucifugus* in April, 1937, in Bat Cave, Carter County, Kentucky. They stated that "in November, 1937, many . . . were examined and 70 banded individuals were found." Although the exact date the bats were banded is not stated, I know it was April 10, 1937.

On February 16, 1939, I examined the colony and recovered six banded individuals. On November 4, 1939, search of the colony revealed 27 banded individuals. On March 15, 1941, I again looked for banded bats in the cave; 13 were observed. Due to stress of other duties, I was unable to visit the cave again until 1945; at this time a thorough search disclosed no bats that had been banded by Welter and his associates. It is of interest to note that in no case did I recover a banded bat more than once.

The thirteen bats recovered March 15, 1941, represented both *Myotis sodalis* and *Myotis lucifugus*, establishing a longevity record of slightly more than three years and eleven months for each species. Logically, this note should have been prepared by Dr. Welter; unfortunately he met an untimely death in 1939.—Roger W. Barbour, *Oglebay Institute, Wheeling, West Virginia. Received November 3, 1949.*

ALBINISM IN BATS

In a small collection of Venezuelan mammals presented to the United States National Museum by Mr. Foster D. Smith, Jr., of Caracas, Venezuela, there is an albinistic specimen of the leaf-nosed bat, *Glossophaga longirostris*. Mr. Smith obtained this specimen (no. 283877) on 20 August 1948 at Cantaura, Anzoategui, Venezuela. On the label was noted "albino bat ♀ iris red . . . with other brown bats in abandoned house."

Only one other albinistic bat, *Antrozous pallidus pallidus*, number 265560, Biological Surveys Collection, was found in the collections of the National Museum. This latter is from Corn Creek Ranch, 26 miles north of Las Vegas, Nevada. It was obtained on 9 February 1940 by S. G. Jewett. No field observations are recorded on the label.

The frequency of albinistic bats in normally colored populations seems to be small. A cursory search of the literature reveals that, including the specimens mentioned above, there are records from every continent except Australia and representing the genera *Rhinolophus, Glossophaga, Myotis, Pipistrellus, Eptesicus, Lasiurus, Antrozous, Chaerephon*, and *Molossus*. Only *Glossophaga* and *Myotis* include more than one species known to show albinism.—Henry W. Setzer, *United States National Museum, Washington, D. C. Received August 15, 1949.*

CHIPMUNK EATS FROG

On October 2, 1949, Richard Stipe, a forestry student at Michigan College of Mining and Technology, was hunting ruffed grouse with two friends in the Pike Lake area, Houghton County, Michigan. It was about five o clock in the evening when Stipe sat down on a log that was laying across a logging trail. In a few minutes a chipmunk, (probably *Tamias striatus*) that was heard scurrying about in the woods, popped out of the brush just in front of Stipe. It seemed quite tame; when he whistled it would stop, look up, then go

about its work again. He was eating little seeds that were abundant, and apparently had little concern for Stipe as he stayed within ten feet of the log. Suddenly, he took a couple of short, quick hops and sort of rooted his nose and head beneath the leaves. He came up with a small frog which was about two inches long. The frog was definitely alive because it squirmed and kicked quite a bit. A couple of quick bites in the head and neck and the frog was killed. The chipmunk then proceeded to eat the frog; he first ate the head, then pulled out the innards and ate them. He had only the back legs to eat when Stipe left.—Gene A. Hesterberg, *Michigan College of Mining and Technology, Houghton, Michigan.* *Received October 14, 1949.*

HABITAT ADAPTABILITY OF *PHENACOMYS* IN WYOMING

It has been thought previously that the distribution of *Phenacomys intermedius intermedius* was more or less restricted to the higher altitudes, usually in boreal habitats, or krummholtz ecotones near timberline. The writer's experience collecting in and around Jackson Hole, Wyoming, shows a far wider distribution in habitats than previously described.

During the summers of 1948 and 1949, quadrats for mammalian population studies were run in Jackson Hole. To the writer's surprise *Phenacomys* was collected in sagebrush quadrats at an elevation of approximately 6700 feet above sea level. The sage flats are quite well drained, and where the cattle have not grazed heavily the soil is rather loose. Since specimens of *Phenacomys* were collected in several different sage localities as much as ten miles apart, it is assumed that their distribution in the habitat is quite widespread.

At 7000 feet elevation one specimen was taken by Mr. A. B. Mickey along a small stream at the edge of a spruce-fir forest near Grassy Lake, just south of Yellowstone National Park. Apparently they were in close association with other microtines here since both *Microtus richardsoni macropus* and *Microtus longicaudus mordax* were collected along the same stream. At about 10,000 feet, near Togwotee Pass, another specimen was taken in a clearing in the spruce-fir forest on a well-drained rocky hillside.

In the lush alpine meadows on Brooks Peak, Fremont County, at an elevation of about 11,000 feet, three quadrats were run for population figures. All failed to produce *Phenacomys*.

The results of the study in Jackson Hole indicate that *Phenacomys intermedius* is more adaptable to habitats than are many of the other voles. It apparently survives well in either moist or xeric conditions. This is not surprising when one considers that *Phenacomys* is one of the primitive vole genera, and might be expected to adapt itself more easily than some of the higher forms.—N. C. Negus, *Dept. Zoology, Miami University, Oxford, Ohio.* *Received October 19, 1949.*

KEEPING SHREWS IN CAPTIVITY

From time to time I receive requests for information on keeping shrews in captivity. Since little has been published on this subject I wish to record some suggestions and cautions. My first remarks refer to the short-tailed shrew, *Blarina brevicauda*.

Of most importance is the speed with which one gets the shrews out of the traps and into cages. Even at moderate temperatures and with adequate food shrews will sometimes die in small cage-traps and box-traps in less than four hours. For cages I prefer rectangular glass-sided boxes with at least 100 square inches of floor space covered with shavings, and with a small glass jar or vial lying on its side to serve as a nest chamber. Only one shrew should be kept in each cage. Water and food should be available as soon as the animals are released in their cages, and they should be encouraged to drink. If a shrew has strength and inclination to drink and can run without wobbling, its chance of survival is good. For food I use a mixture of raw hamburger or ground horsemeat, ground raw liver, dog food (dry meal such as Gaines, Purina, or Friskies), and water mixed together to hamburger consistency. I usually take about equal volumes of meal and meat and add water to make the proper consistency. Exact proportions are not necessary. Enough food for several days can be mixed at one time and kept refrigerated. Short-tailed shrews will eat enormous numbers of natural food items such as earthworms, sowbugs, Japanese beetles, and grass-

hoppers, but I feel that these are not as satisfactory a food as the prepared mix, and it is tedious to gather them in the necessary numbers.

I have heard and read many reports of captive shrews dying suddenly from fright, exposure, and other causes. Such individual shrews must be exceptional, for I have never seen a similar occurrence even among shrews subjected to surgery, photography in bright sunshine, falls from tables, and loud noises. One *Blarina* survived when its cage, a one-gallon cracker can, was run over by an automobile. Dozens of ovariectomies revealed a considerable resistance to shock and infection, but, under ether, a rather narrow twilight zone between light anesthesia and death.

The above suggestions are applicable to long-tailed shrews (*Sorex*) with the exception that it is frequently necessary to teach them to like the food mixture. I usually give them some invertebrates to ease the transition to captivity, or a dead mouse with the liver and brain exposed. As soon as possible they should have available some raw brains mixed with a small amount of dog food. In the absence of brains, ground liver may be used, or even a chunk of liver. Day by day more dog food, liver, and hamburger can be added to the original brain mixture. Such treatment has proven effective in keeping *Cryptotis*, *Sorex cinereus*, *S. ornatus*, *S. vagrans*, *S. pacificus*, *S. trowbridgii*, and *S. palustris* healthy for weeks or months. Deaths have usually been from experimentation or neglect. *Blarina* has survived as long as 33 months on the diet described above, supplemented only rarely with invertebrates.—OLIVER P. PEARSON, *Museum of Vertebrate Zoology, University of California, Berkeley, Calif.* *Received October 17, 1949.*

NOTES ON THE PHILIPPINE TREE SHREW, *UROGALE EVERETTI* THOMAS

The tree shrews discussed in this article were taken near the village of Todaya on Mt. Apo, southeastern Mindanao. All were caught by snare or box trap in runways on river gorge hillsides bordering the Sibulan River. Most of the specimens were caught in proximity to streams near the base of certain food trees in a surrounding of Taro, tree ferns, and other luxuriant growth.

As near as could be determined, the following plants are utilized as food by shrews in the wild: kamote, *Ipomoea batatas* (Linn.); sangi, *Ficus carpenteriana* Elm; dalikan, *Amomum dalican* (Elm); sageen, *Musa* sp; karambong (unidentified); and panuda (unidentified). They feed principally in the mornings; most of those trapped were caught between 8:30 and 9:30 A.M. Tree shrews are excellent climbers. On the ground they move from cover to cover with great speed in a series of incredibly swift runs. We had good opportunity to observe their actions on the several occasions when caged animals escaped in Davao and had to be retrapped. One such elusive individual lived for several days nearby before he was seen. His hideout was found to be in the bottom of a pit, the sides of which contained numerous holes, presumably of rodent origin. Natives state that tree shrews nest in the ground or in cliffs, the latter being common in their habitat.

In captivity tree shrews rarely actually fight, but they do considerable whimpering and squealing. When first captured males seemed to be the more inquisitive and would rush to the front of their cage to whimper, spit, or make a characteristic explosive snort, all the while making quick little scratching motions, with the front feet, at a hand held close to the wire.

The most satisfactory cage was about a foot square, with a large mesh false bottom of large mesh hardware cloth. Since shrews are messy with their fruity foods cages quickly get wet and the incessant activity of freshly-caught animals may cause sore spots on the feet. A concrete cage floor and the use of excessive water in cleaning may bring about the same condition in the zoo.

Shrews lap water, and use a great deal. They usually sleep curled in a tight ball, often with the top of the head directly underneath the body. They tame readily and will poke their long noses around and between your fingers, seeking food, when the hand is placed in the cage. They may be grabbed and handled with little danger to themselves, but are powerfully muscled and difficult to hold. They will bite when first handled, but soon learn to trust their attendant; they always protest vocally.

They have two common calls, besides whimpering and snorting; one a series of chirping squeals and the other a long, drawn-out distress call which reminds one of the far-off cry of a red-tailed hawk. They may occasionally utter a meow which is startlingly cat-like in quality.

On being given a piece of meat an animal will dash wildly about the cage holding the meat in its mouth, coming back to the door still holding the morsel, to see if something else will be offered. They are most omnivorous. Their list of foods is formidable. Live foods, as follows, have been fed to them: mice (one female in the Philadelphia zoo regularly consumes two mice at one feeding); lizards, dead or alive; insects, adults and larvae; dried locusts; earthworms. A list of fruits eaten includes: banana; guava, *Psidium guajava* Linn.; papaya, *Carica papaya* Linn.; tesa; mango, *Mango indica* Linn.; sargolias, *Spondias purpurea* Linn.; pineapple; prunes; oranges; raisins; and apples. Other foods consist of raw meats of all kinds, chopped, in mixtures, or plain; oatmeal on bananas; eggplant, avocado; corn, young green, and popcorn; sweet potatoes, cooked; peanuts, boiled or roasted; coconut; rice, cooked; egg, raw or coddled; and milk.

In the Philadelphia Zoo a female consumes daily one-fourth orange, one-fourth apple, one and one-half ounces of a meat mixture, and one-half ounce of "zoo cake," a cereal meal mixture. Tree shrews have such prodigious appetites that they can finish a whole banana or a two ounce piece of raw beef several times daily.

The Philadelphia Zoological Garden had three litters born in 1948: two young on February 19; two on April 15; and one on August 30. All were killed by the mother. In the New York Zoological Park two young were born October 7, 1947, and left with the mother. One died two days later, and one eight days later. Another youngster was born December 10, and was taken from the female and successfully hand reared until an unfortunate accident caused its death on December 23. Two more were born to this pair on August 29, 1948, and left with the mother. They were perfectly reared, but died near the first of October shortly after emerging from the nest box.

The female in the Chicago Zoological Park had a stillborn young on May 3, 1948. Fifty-four days later a young male was born which died of an injury at three months of age (Snedigar, Robert. Jour. Mamm., 30: 194–95, 1949), when it weighed 185 grams. The weight of a male tree shrew is approximately 350 grams. Another was born to the same pair on December 14, but had disappeared on the tenth day. An incident worth recording followed this birth, which occurred at 1:00 P.M. At 2:30 P.M. the female showed extreme excitement and tried to enter the male's cage under the partition which separated them. When Mr. Snedigar opened the cage and placed his hand inside the female climbed on it, rubbed with her belly, and showed other signs of sexual excitement. Because of increasing activity of this nature, the nest box was blocked off and the partition raised. Copulation occurred at least ten times for the next hour and a half, before the animals were again separated. Copulation is remarkably continuous throughout the oestrus, and apparently follows parturition closely. The gestation period appears to be approximately 56 days.

On May 28, 1947, hair was first noticed missing on captive shrews. On May 31, a bald patch was noted on top of the head of one individual. Pressure from the sleeping position and improper diet were suspected. Several animals were transferred to a dirt-floored cage. Here they exhibited tendencies to root and dig like miniature pigs. Although the name of the animal "Terrababui" is used by the Bogobos it has no interpretation in that language; in Visayan it means "earth pig."

Following the use of vitamin preparations hair was first noticed reappearing for the first time on June 16, 1947. These bare patches would often include the entire hind quarters and tail, as well as the top of the head. It was believed to be other than the normal moult later observed in caged shrews in the United States. The inclusions of more foods such as earthworms and larvae of the rhinoceros beetle (*Orycetes*), and the administering of vitamin-mineral solutions are believed to have brought the eleven afflicted animals back to normal by the first of July.

The writer sincerely appreciates the information received from Frederick A. Ulmer, Jr., Philadelphia Zoological Garden; Robert Snedigar, Chicago Zoological Park; and Lee

Crandall of the New York Zoological Park.—CHARLES H. WHARTON, *Dept. of Biol., Emory University, Georgia.* *Received October 22, 1949.*

CONGENIAL RELATIONSHIP BETWEEN RACCOON AND WHITE RAT

Although there are numerous accounts of congenial relationships between animals of different groups, the circumstances attending the following relationship between a male raccoon (*Procyon*) and a male white rat (*Rattus*) make it an unusual one. The raccoon was caught as a yearling in April, 1949, near Amherst, Massachusetts, and was kept in captivity in the laboratory of the Department of Forestry and Wildlife Management of the University of Massachusetts at Amherst. During the first two and one-half months of the raccoon's captivity its diet, consisting of a variety of vegetable and animal materials, included several live mice and three or four white rats, all of which were eaten when offered. About the end of June a rat, offered in the usual manner, was neither eaten nor harmed in any way. No indication of fear was noted on the part of either animal, and an apparently close attachment developed between them. They live in the same cage and share the same food. The raccoon spends much of its time in a small wooden box within the cage, and the rat, when not exploring the cage, is usually observed curled up beside the raccoon, frequently between its forepaws or on its back. Often when the two animals are curled up together the raccoon licks the rat's fur. The raccoon and rat have lived together now for more than seven months; and during this time no other rats have been offered, though mice have been offered to and eaten by the raccoon. In view of the fact that the rat concerned was offered as food during an active, or non-hibernating, period for the raccoon and considering also that the raccoon had previously eaten white rats, this relationship between the two animals seems particularly interesting.—ROBERDEAU CALLERY, *Department of Zoology, Smith College, Northampton, Massachusetts.* *Received February 27, 1950.*

[Contribution from the Department of Zoology, Smith College, no. 224]

BADGER-COYOTE "PARTNERSHIPS"

Participation of badgers and coyotes in hunting activities has been seldom recorded. Weldon B. Robinson and Maynard W. Cummings (Jour. Mamm., 28: 64, 1947) described two instances of pairs of these dissimilar animals associating together in Yellowstone National Park. J. Frank Dobie ("The Voice of the Coyote," 1949, pp. 56–65) also related an incident of this type which he had witnessed personally, and added several accounts which had been given him by other persons. Mr. Dobie concluded that "there seems to be a kind of mutual attraction, an obscure rapport," between coyote and badger.

During November, 1949, four instances of association in hunting activities by the two species came to my attention.

On November 6, I was in the north unit of Theodore Roosevelt National Memorial Park about forty miles south of Williston, North Dakota. The custodian, Mr. Loren Clark, told me that that morning he had visited a prairie dog colony near Squaw Creek, about one-half mile north of the Little Missouri River and four and one-half miles west of the Belfield-Williston highway (U. S. 85). Near the border of the "dog town" a badger and a coyote were standing close together. At the moment, they were watching a bobcat which was perched in a low tree feeding on a prairie dog.

The following day, November 7, a group of which I was a member was driving through the south unit of the park about four and one-half miles east-northeast of Medora, North Dakota. At the junction of the north and south forks of Paddock Creek we drove around a sharply curved hill or ridge and into a prairie dog colony. Our sudden appearance startled a coyote and a badger which evidently had been hunting the big rodents. When I sighted the predators they were about fifty feet apart and already alarmed. The coyote, a beautifully furred animal, was running away toward the hill on the south side of the valley. The badger was in the act of backing hastily out of a prairie dog den. It galloped a short distance north, then dropped into another hole in the ground.

After we left this "dog town," I examined it through binoculars from a hill a quarter of a mile away in the hope that the predators might return to their hunting. While I watched, a prairie dog popped out of a den some twenty or thirty feet from the hole in which the badger had disappeared. Without pausing, the prairie dog raced at full speed to a burrow about fifty feet further away and dropped into it. No cause for the animal's haste was evident. I assumed that it might have been alarmed by the approach of the badger under ground. It was plain, however, that a watchful coyote would have been in a strategic position to profit by "partnership" with an industrious badger.

When we returned to park headquarters late that day, we were told by Ranger William J. Briggle that he had ridden on horseback through this prairie dog colony about three hours before our visit. As he came in view, he saw a coyote and a badger each catch a prairie dog. According to Mr. Briggle, the two predators simultaneously rushed through the colony and snatched at the frightened "dogs" as they ran for shelter. The badger "rode down" his prey at the entrance of a den and dropped into the hole in one continuous movement. The coyote and badger seen by Mr. Briggle may have been the same animals which we observed later in the day. It is interesting that the dissimilar hunters had adopted the stratagem of the "double rush" which is used successfully by two or more coyotes when hunting prairie dogs.

Three weeks after the above incidents, Mr. J. Estes Suter, Superintendent of Badlands National Monument, told me of another badger-coyote affiliation. This observation was made about November 10, 1949, near the town of Interior, South Dakota. Mr. Suter was driving on a country road which was immediately south of the national monument and parallel to the Chicago, Milwaukee, St. Paul, and Pacific Railroad. Seeing a coyote on the railroad embankment less than one hundred feet away, Mr. Suter stopped to watch it. His attention then was attracted to a movement in the weeds near the coyote. By using binoculars, he identified the nearly concealed animal as a badger. The latter nosed about busily, pursuing an erratic course through the tangle of grass and weeds on the top and sides of the embankment. It appeared to pay no heed to the coyote and twice passed it within inches. The larger animal watched the badger intently, however, and slowly moved along to maintain its position near the hunter. After a few minutes the badger gave up its search for prey and the two animals walked off side by side between the rails (to use Mr. Suter's descriptive phrase) "like a pair of hobos."

It seems possible that coyotes may "team up" with badgers more commonly than is indicated by the marked physical differences in the two species. Such associations may be rarely noticed for several reasons. Coyotes are generally wary as a result of almost universal persecution outside of national parks and, therefore, are seldom observed while acting in a normal manner. Badgers have become rare over wide areas, due to poisoning and trapping, and are not often seen. The survivors are shy and take to the ground on the least alarm. It would be desirable to learn whether coyotes and badgers generally are apt to form some type of association. It would be interesting also to discover if such associations are harmonious and if each "partner" benefits in the fruits of the hunt.—Victor H. Cahalane, *National Park Service, Washington 25, D. C.* *Received January 8, 1950.*

A BADGER PREYING UPON CARP

On August 26, 1949, the senior author witnessed an instance of badger predation on carp, which occurred at the Seminoe Reservoir in central Carbon County, Wyoming. The incident took place near the southern end of the Reservoir, on Platte River, at about 6000 feet altitude.

While eating lunch on the bank of the Reservoir, two animals were seen swimming among the brush and debris a short distance from shore. Soon both came to shore near by and were identified as badgers (*Taxidea taxus*), apparently not quite fully grown. One disappeared in the brush on the bank, and the other settled itself in a clump of greasewood that extended over the water. It remained there without moving for over an hour, staring down at the water. Finally it slid carefully out of the greasewood and disappeared quietly into the water.

In a few minutes it again came to view from among the partly submerged bushes which extended out from shore, carrying a fat carp in its mouth. In spite of the floundering of the fish, the badger had no trouble in beaching it, carrying it by the belly about midway between head and tail.

After photographing the animal, it was approached, whereupon it dropped the fish and ran away. The photographs, although unsuitable for enlargement and printing, show the badger bringing the carp to shore, and give the impression that the fish is about one-fourth to one-third the weight of the badger. The size of the carp was estimated as between 14 and 16 inches long and about three pounds in weight. It was a very plump fish.

Although the aquatic foraging habits of badgers are fairly well known, this is to our knowledge the first recorded instance of badger predation on fish. Subsequent inspection of the shores of Seminoe Reservoir revealed numerous signs of badger fishing adjacent to the initial site.—Guy E. Drake and Clifford C. Presnall, *Fish and Wildlife Service, Casper, Wyoming, and Washington, D. C. Received January 6, 1950.*

DOMESTIC CAT PREDATION ON SHORT-TAILED WEASEL

On July 24, 1948, while the University of Michigan Museum of Paleontology field party was camping on the W. T. Faris Ranch, Dell Creek, Sublette County, Wyoming, Mr. Faris brought to our camp the head of a weasel which he explained was all that he was able to recover from one of their house cats. Mr. Faris said that these weasels were fairly common and that they were frequently caught and eaten by the cats. We asked him to try to save an entire specimen, and on July 26 Mrs. Faris recovered an entire weasel from one of the cats. This specimen was later identified as a male *Mustela erminea muricа* (Bangs). The specimen was prepared into a study skin and is in the University of Michigan Museum of Zoology mammal collection, number 95851. The skull from the first specimen is of the same species and is museum number 95852.—George R. L. Gaughran, *Department of Zoology, University of Michigan, Ann Arbor, Michigan. Received January 11, 1950.*

THE GESTATION PERIOD OF THE PIKA (*OCHOTONA PRINCEPS*)

In 1946 I began a study of the natural history of the pikas. A determination of the gestation period was one objective since, to my knowledge, there is no published record of it. To accomplish this it was first necessary to learn how to keep and propagate pikas in captivity. Sufficient success was attained during the spring and summer of 1949 to state unequivocally the length of the gestation period for one captive litter of *Ochotona princeps muiri* Grinnell and Storer. The parents were trapped and the young reared at Bodie, elevation 8374 feet, Mono County, California.

A female (No. 14) was caught on May 29. On June 4 she gave birth to a litter of four healthy young. Having learned previously (Severaid, Jour. Wildlife Mgt., 9:291, 1945) that the day of parturition, or the day following it, is the best and surest time at which to secure matings between captive snowshoe hares, it was conceivable that the pika might react likewise. Consequently, I placed a male (No. 13), caught on May 28, in the female's pen at 12:00 noon on June 5. At 12:10 P.M. a mating was observed between this pair. Two more observed coitions followed, one at 12:13 P.M. and the other at 12:50 P.M. Observations were terminated at 1:10 P.M. Unobserved breeding was also possible during this period as the pikas were not always in my view. The male was separated from the female at 11:10 A.M. on the following day, June 6. This female never had another male available to her during the ensuing weeks, during which time she nursed three of her young for fifteen days after which only one nursing young survived through and beyond her next parturition. She gave birth again between 11:00 P.M., July 5, and 7:00 A.M., July 6. Her second captive litter contained two healthy young. Thirty and one-half days had elapsed, at midnight, since the female was first observed bred by the male on June 5. Therefore, the gestation period for this litter was between 732 and 739 hours, or 30½ days plus some unknown number of hours, not exceeding seven (assuming the litter was born after midnight).

The gestation period is known for at least five other lagomorphs. It is 28 (26–30) days for cottontail rabbits (*Sylvilagus*), this average and range being mine based on data supplied

by Dice (Jour. Mamm., 10:227, 1929), Haugen (Amer. Mid. Nat., 28:213, 1942), and Hendrickson (Ames Forester, I.S.C., 21:62, 1943). For *Oryctolagus cuniculus*, the European wild rabbit, it is 29 (28–30) days (Southern, Ann. Appl. Biol., 27:518, 1940) as compared with 32 (29–35) days for the domestic varieties of these rabbits (Templeton, *et al.*, Conservation Bull. No. 25, U.S.D.I., F.W.S., P. 16, 1942). In the snowshoe hare (*Lepus americanus*) it is 37 (36–40) days (Severaid, Jour. Wildlife Mgt., 9:290, 1945), and for the California jack rabbit (*Lepus californicus eremicus*), also a hare, it is 43 (41–47) days (Haskell and Reynolds, Jour. Mamm., 28:135, 1947). It is thus seen that the gestation period of the pika is closer to that of the rabbits than it is to that of the hares. This does not necessarily imply a close relationship. Perhaps, the fact that young pikas are altricial does indicate a closer relationship to the rabbits than to the hares, the latter being precocial.—J. Harold Severaid, *Museum of Vertebrate Zoology, University of California, Berkeley 4, California.* *Received November 23, 1949.*

MAMMAL HOST RECORDS OF ACARINA AND INSECTA FROM THE VICINITY OF HAMILTON, ONTARIO

During the summer months of 1947 and 1948 ectoparasites were collected from mammals in the vicinity of Hamilton, Ontario, in connection with a survey of wildlife of Wentworth County, sponsored by the Research Council of Ontario and conducted by the Department of Zoology of McMaster University, under the direction of Professor A. E. Warren. The main source of parasites was a collection of small mammals made during the same period in Wentworth County by Mr. L. A. Prince, assisted by Miss Mary Inksetter. Mr. Prince kindly supplied the identifications of the mammals and Miss Inksetter removed parasites from them when they were brought into the laboratory. Mr. R. Sharp and Mr. G. Sweatman contributed parasites from muskrats trapped in the Dundas Marsh near Hamilton. Miss Helen Eydt prepared the specimens for study and distributed them to specialists in the taxonomy of the various groups.

Materials and Methods

Small mammals were trapped in various habitats. Each mammal, when removed from the trap, was placed in a paper bag which was rolled up to prevent escape of parasites. The date and the name of the locality of collection were written on the bag. The contents of the bag were emptied over a clean sheet of paper or an enameled tray and any live parasites which appeared were captured. Parasites remaining on the animal were picked off with forceps or were brushed off with a small brush, and parasites which fell onto the paper or tray were gathered. Ticks and mites were placed in vials containing a solution mixed in the following proportions: 870 cc. of 70 per cent alcohol, 50 cc. of glycerine, 80 cc. of glacial acetic acid. Insects were put into vials containing 85 per cent alcohol. Each vial was labelled with the catalogue number of the mammal from which the parasites contained in it were taken. Ticks and mites were left in the preservative, to be sent to specialists for identification, while insects were mounted on slides in Canada balsam. Identifications of the parasites were made by taxonomic specialists whose kind co-operation made possible the completion of the work. Dr. H. H. J. Nesbitt of Carleton College, Ottawa, identified the mites, Mr. J. D. Gregson of the Dominion Livestock Insect Laboratory, Kamloops, B. C., identified the ticks, and Mr. C. F. W. Muesebeck, Chief of the Division of Insect Identification, U. S. Department of Agriculture, identified the fleas.

All localities mentioned in the following list are in Wentworth County, Ontario, except Jaffa which is in Elgin County and Campbellville which is in Halton County. All specimens of parasites are in collections at McMaster University except those retained by specialists who identified the specimens, and all mammal skins are in a collection at McMaster.

Acarina

Laelaptidae

Atricholaelaps glasgowi (Ewing).—Found on *Zapus hudsonius ontarioensis* Anderson, Dundas, May 28, 1947; *Microtus p. pennsylvanicus* (Ord), Dundas, May 28, June 3, 9, 11,

13, 1947, July 13, 1947; Hamilton, July 23, 1947; *Peromyscus* sp., Dundas, July 5, 1947, July 8, 9, 1948; *Pitymys pinetorum scalopsoides* (Audubon and Bachman), Jaffa, Ontario (Malahide Twp., Elgin Co.), Aug. 19, 1948, Dr. Peter Henderson; *Rattus norvegicus* (Berkenhout), Hamilton, July 22, 1947.

Laelaps microti (Ewing).—Found only on *Microtus p. pennsylvanicus* (Ord), Dundas, May 28, June 3, 9, 12, 13, 1947; Waterdown, July 1, 1947; Hamilton, July 24, 1947.

Laelaps muris Ljungh.—The following hosts are represented: *Microtus p. pennsylvanicus* (Ord), Dundas, May 28, June 12, 13, July 13, 1947, Hamilton, July 23, 1947; *Ondatra z. zibethica* (Linnaeus), Dundas Marsh, June 26, 28, Aug. 12, 1948.

Eulaelaps (Hypoaspis) stabularis (C. L. Koch).—Host: *Peromyscus* sp., Freelton, June 21, 1947.

Haemogamasus hirsutus Berl.—Host: *Zapus hudsonius ontarioensis* Anderson, Freelton, June 21, 1947.

IXODIDAE

Ixodes cookei Packard.— Host: *Marmota monax rufescens* Howell, Campbellville, Ontario (Nassagaweya Twp., Halton Co.), June 26, 1947.

Ixodes angustus Neumann.—Host: *Peromyscus* sp., Dundas, July 8, 9, 1947.

INSECTA

SIPHONAPTERA

DOLICHOPSYLLIDAE

Orchopeas leucopus (Baker).—Host: *Peromyscus* sp., Dundas, June 10, 1947; Freelton, June 21, 1947.

Oropsylla arctomys (Baker).—Host: *Marmota monax rufescens* Howell, Copetown, June 28, 1947; Flamboro Station, July 3, 1947.

Nosopsyllus fasciatus (Bosc).—Host: *Rattus norvegicus* (Berkenhout), Hamilton, June 19, July 22, 1947.

HYSTRICHOPSYLLIDAE

Tamiophila grandis (Rothschild).—Host: *Tamias striatus lysteri* (Richardson), Aldershot, June 24, 1947.

Ctenophthalmus pseudagyrtes Baker.—Host: *Microtus p. pennsylvanicus* (Ord), Hamilton, July 23, 1947.

HEMIPTERA

CIMICIDAE

Cimex pilosellus (Horvath).—Host: *Lasionycteris noctivagans* (LeConte), Hamilton, August 31, 1948.—W. W. JUDD, *Department of Zoology, McMaster University, Hamilton, Ontario, Canada.* *Received December 30, 1949.*

THE MAMMALS OF DRUMMOND ISLAND, MICHIGAN

Drummond Island, with an area of 128 square miles, lies at the extreme northern tip of Lake Huron. Detour Passage, a channel one mile wide, separates it at the west from the mainland of Michigan's Upper Peninsula, while with Cockburn and Manitoulin Islands it forms a chain stretching eastward to the mainland of Ontario, Canada. To the north, Potagannissing Bay, an enlargement of the St. Marys River, is studded with satellite islands and merges into the North Channel. Drummond Island is largely forested, with northern conifers, sugar maples, and beeches predominant; there are scattered meadows, swamps, bogs, and ponds. Some logging has been done, there have been a few attempts at agriculture, and since 1945 an extensive quarry has been developed at the western end of the island. The greatest elevation is upwards of 100 feet above the surrounding waters. The climate is northern in character, and the waters about the island regularly freeze over each winter.

There is scarcely any mention in the literature of the mammal fauna of Drummond

Island. W. H. Burt (The Mammals of Michigan, Univ. Mich. Press, 1946) gives no actual records for the island. During July, 1949, incidental to a study on one of the outlying islands in Potagannissing Bay, I made some observations on the mammals of Drummond Island and collected specimens of *Sorex c. cinereus*, *Blarina brevicauda kirtlandi*, *Myotis l. lucifugus*, *Peromyscus maniculatus gracilis*, *Microtus p. pennsylvanicus*, and *Mus musculus*. Information from local residents has added further to our knowledge of the island mammals. My principal informants were John La Pointe, of Johnswood, who was born and has lived for most of sixty years on the island, and is more than casually interested in wildlife; and Floyd Seaman, a native of the island and postmaster at Drummond Settlement.

Among the small mammals of Drummond Island are the star-nosed mole (*Condylura cristata*), masked shrew, short-tailed shrew, and little brown bat. The red squirrel (*Tamiasciurus hudsonicus*) is a conspicuous resident, reported by many people to sometimes reach astounding numbers not only on Drummond Island, but also on the smaller islands to the north. The flying squirrel (probably *Glaucomys sabrinus*) is also present. Other established rodents include the woodland deer mouse, red-backed vole (*Clethrionomys gapperi*), meadow vole, and the introduced house rat and house mouse, neither of which is abundant. An attempt was made, some years ago, to introduce the gray squirrel. A pair released on the island never appeared to multiply.

The principal fur-bearers of the island are the mink (*Mustela vison*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethica*). Of these, the beaver is now considerably reduced in numbers due to trapping. Otter (*Lutra canadensis*) are still taken occasionally. Weasels (probably *Mustela erminea*) occur on the island, as do red foxes (*Vulpes fulva*) with an occasional variant, the cross fox. Coyotes (*Canis latrans*) have increased in numbers in recent years; six were killed on the island during the winter of 1948–49. Timber wolves (*Canis lupus*) were formerly more numerous; one killed on the north shore of the island during the same winter was thought to have crossed the ice from Canada. The Canada lynx (*Lynx canadensis*) was present until perhaps fifty years ago. The bobcat (*Lynx rufus*) still persists, two having been killed on the island during the past year. Snowshoe hares (*Lepus americanus*), a favorite of many hunters, are common and widespread over the island.

By far the chief big-game animal is the white-tailed deer (*Odocoileus virginianus*). Hunting has been good for over twenty years; during the 1948 season, 1602 hunters killed 416 bucks on the island. Until about forty years ago, however, deer were absent on Drummond Island and the islanders went to the vicinity of St. Ignace on the mainland to hunt them. La Pointe suggested that the custom of hunting them with dogs, then prevalent in neighboring Canada, may have forced them to cross to Drummond Island for sanctuary, swimming across from island to island. They still move freely between the various islands in this manner. La Pointe further reported that, although he never actually saw one alive, both the moose (*Alces americana*) and caribou (*Rangifer caribou*) were still present within his memory, but have since disappeared. Black bears (*Ursus americanus*) still are present in small numbers; several were shot on the island in the past year.

Notably absent from the Drummond Island fauna are the raccoon (*Procyon lotor*), striped skunk (*Mephitis*), badger (*Taxidea*), woodchuck (*Marmota*), chipmunks (*Eutamias minimus* and *Tamias striatus*), gray and fox squirrels (*Sciurus*), meadow jumping mouse (*Zapus*), and porcupine (*Erethizon*), all of which are recorded from Chippewa County on the adjacent mainland. More thorough collecting may disclose additional shrews, bats, and rodents on Drummond Island. Several of these unrepresented species are hibernating forms, and others possibly travel less widely in winter than in summer. This suggests that movement across the ice has accounted for the presence of many of the small mammals which occur today on the island. As for the larger species, crossing either on the ice or by swimming would readily account for the population established at present on Drummond Island.—Richard H. Manville, *Department of Zoology, Michigan State College, East Lansing.* *Received September 7, 1949.*

SOME MAMMALS FROM HART COUNTY, KENTUCKY

The writers spent the first three days of December, 1939, collecting mammals in the vicinity of Canmer, Hart County, Kentucky. As a whole, very little is known of the mammals

of Kentucky; the distribution of many species in the state is completely unknown. The data obtained, though meager, are of more than passing interest to anyone actively interested in the distribution of the mammals within the state.

Five species were collected; all specimens are in the writer's personal collection. In the following annotated list all measurements are given in millimeters; averages are given first, followed by extremes in parentheses.

Cryptotis p. parva (Say).—A single specimen of the little short-tailed shrew was trapped from a pile of rocks in a brushy fence corner.

Peromyscus l. leucopus (Rafinesque).—Seven specimens were collected; all agree with the characters of *leucopus*. Specimens were secured from such diverse habitats as an alfalfa field, a weedy pasture, a dense tangle of *Lonicera*. and open deciduous woodland. Measurements of seven adults are: Total length, 157.3 (142–182); tail, 67.7 (61–81); hind foot, 19.6 (18.5–21).

Microtus ochrogaster (Wagner).—Twelve specimens of the prairie meadow vole were taken. All but one exhibit the characteristic buffy belly. No individuals were taken from wooded areas, but they were abundant in open fields. Numerous fields in the area were overgrown with *Rubus* and *Andropogon*; runways of this species were extremely abundant in such areas. Most of our specimens were taken from these old fields, but individuals were taken from runways in fields of uncut alfalfa. Average measurements of four adults are: Total length, 145 (142–149); tail, 32 (28–35); hind foot, 19.7 (19–20). Three size groups are recognizable in the twelve specimens; the largest specimens, noted above, are quite grizzled in appearance. A smaller group, represented by seven specimens, averages: Total length, 120.4 (112–126); tail, 24.8 (22–28); hind foot, 18.2 (18–19). Of this group, five are nearly uniform dorsally; the remaining two are beginning to exhibit the grizzled appearance of the adult. The third size, represented by a single specimen, measures: Total length, 98; tail, 17; hind foot, 15. This individual was collected December 3, indicating that parturition extends probably into November, if not later.

Pitymys pinetorum auricularis (Bailey).—Four pine voles were taken, all from well-worn surface runways in old fields where the dominant vegetation was a mixture of *Rubus* and *Andropogon*. The runways were indistinguishable from those of *Microtus*, if in fact not identical. In one case *Microtus* and *Pitymys* were taken the same night from a single runway, separated by no more than a few feet. Measurements of four adults are: Total length, 123 (114–127); tail, 21.1 (19–24); hind foot, 16.9 (16–18).

Sylvilagus floridanus mearnsii (Allen).—Cottontails were quite numerous in the overgrown fields about Canmer. The single specimen taken agrees in general with the characters of *mearnsii*.—ROGER W. BARBOUR AND BERNICE L. BARBOUR, *Oglebay Institute, Wheeling, West Virginia.* *Received October 17, 1949.*

MAMMALS OBSERVED IN THE YUKON TERRITORY, CANADA, IN THE SUMMER OF 1949

While employed with the Northern Insect Survey, sponsored by the Defence Research Board and the Department of Agriculture of Canada, the writer had an opportunity to observe a few mammals in the Yukon Territory of Canada during June and July of 1949. The centre from which observations were made was Dawson, located on the Yukon River near 64° 10′N, 139° W. Trips were made along various roads leading out of Dawson. The Sixtymile Road starts at Dawson and runs westward for a distance of about sixty miles to Poker Creek in Alaska. Another series of roads leads eastward and southeastward along the Klondike River, Hunker Creek, Dominion Creek, and Sulphur Creek, all within forty miles of Dawson.

Ursus americanus Pallas.—A black bear was seen in a patch of dwarf birch at mile 13 of the Sixtymile Road on June 26. When disturbed it made off down the slope of an adjoining gully. On July 14 a bear cub was seen moving along a road skirting a meadow near Dawson, and on July 22 a large bear vaulted across the road in front of an approaching truck about three miles east of Dawson. All these bears were black.

Marmota monax ochracea Swarth.—A reddish brown woodchuck was observed on June 18 at the mouth of a burrow near the side of a road along Hunker Creek. The next day, June 19, a woodchuck scrambled across the road at the same sopt.

Tamiasciurus hudsonicus (Erxleben).—A squirrel, grayish in colour, was chattering in a tree at the side of the road along Hunker Creek on June 18. A rusty red squirrel scolded and scampered about in the trees along Sulphur Creek on June 19 and another, streaked with rusty red and gray, chattered from trees at Mile 31 of the Sixtymile Road. During the week of May 31 to June 6 a large midden was observed in a spruce wood at Whitehorse in the southern part of the Yukon. It was composed of myriads of scales from spruce cones forming a layer over several square yards beneath the trees. It was penetrated by holes leading into tunnels about the roots of the trees.

Castor canadensis Kuhl.—A beaver, seen swimming in a pool in a wide sphagnum bog along Dominion Creek on June 18, dived when it detected observers. At the edge of the pool a flat plank projected into the water and on its end was a "sign heap" consisting of a flattened pile of mud about six inches in diameter and with a few broken rushes projecting from it.

Lepus americanus Erxleben.—A grayish brown hare was seen sitting upright in the middle of a woodland road near Dawson on July 14. It remained motionless until observers approached to within thirty feet of it when it padded off slowly into the woods.

Rangifer arcticus (Richardson).—No caribou were seen by the writer during the two months in which observations were made. Along the Sixtymile Road, skulls and antlers of caribou were frequently seen on the ground. A prominent feature of the topography along this road is a series of rounded eminences, locally known as "domes," of elevation 3000 to 5000 feet. Two trips were made along this road, one over the week-end of June 26 and the other over the week-end of July 10. On these occasions individual antlers or skulls complete with antlers were seen lying in the birch scrub around the slopes of the domes at the rate of one or two per mile. They were worn to a dull gray colour and in many cases the parts close to the ground were covered with moss.—W. W. Judd, *Department of Zoology, McMaster University, Hamilton, Ontario.* *Received October 31, 1949.*

TWO NEW MAMMAL RECORDS FROM THE VICINITY OF WELAKA, PUTNAM COUNTY, FLORIDA

Moore has published two lists of mammals from the University of Florida conservation Reserve at Welaka, Florida (Jour. Mamm., 27: 49–59, 1946; *Ibid.*, 30: 57–66, 1949). Additional notes on two species are recorded below.

Neotoma floridana floridana (Ord).—A female woodrat was taken on June 5, 1948, from a small isolated patch of river swamp directly north of John's Landing and adjacent to the St. Johns River. The weight was 143 grams. There was no indication of lactation or pregnancy. As far as I have been able to determine this is the second record of the woodrat for Putnam County, the first being that of Goldman (N. A. Fauna, 31: 22, 1910) from San Mateo.

Dasypus novemcinctum mexicanus Peters.—In view of the paucity of records of the armadillo in the vicinity of Welaka, prior to 1942, the following data are noteworthy as a further indication of the rapid establishment of this animal in Florida, a fact brought out by Sherman (Fla. Ent., 26: 54–59, 1943) in his discussion of the introduction and spread of the armadillo in the state within the last thirty years. Moore (*op. cit.*, 1946) records an armadillo, killed by negros, ". . . about halfway between Crescent City and Welaka in March, 1942." He cites no records for the reserve.

Sherman (*op. cit.*, 1943) records two armadillos being killed in a swamp near Crescent City, one in 1938 the other about two years earlier. Julius Melchior, a landowner living approximately three miles southeast of the reserve, has the dried shell of an armadillo that he killed in his orange grove in 1947. Another one of these animals was brought to me on May 30, 1948, by Clifford Collins. He had run over this animal about ten o'clock in the evening on the highway about one mile south of the reserve. It was a female, and though not pregnant, appeared to have been nursing recently.

On June 2, 1948, I saw two armadillos in a mesic hammock near the southeastern corner of the reserve. One, a female, was captured; the other escaped. Mr. Lover Cash, a resident of the nearby settlement of Satsuma, killed two armadillos in his garden during the month of July, 1949. There have also been reports from other reliable individuals of several of these animals being killed by automobiles in the Dunn's Creek area which is eight miles north of Welaka.—GEORGE H. POURNELLE, *Department of Biology, University of Florida, Gainesville, Florida.* *Received September 10, 1949.*

EARLY RECORDS OF CALIFORNIAN MAMMALS

Mr. Chapman Grant's note on "An early reference to the California pocket gopher" (Jour. Mamm., 30: 318, 1949) based upon a quotation from "Cosmography . . . of the Whole World . . . by Peter Heylin . . . London . . . 1682." has stimulated the writer to call attention to an earlier reference to obviously the same animal.

The basis for Heylin's reference, as indeed those of other earlier authors including Samuel Purchas in "His Pilgrimes" (vol. II, pp. 139–140, 1625), goes back to Richard Hakluyt's "The Principal Navigations, Voiages and Discoveries of the English Nation . . . ," printed in London in 1589. Inserted between pages 643 and 644 of Hakluyt's work is "The famous voyage of Sir Francis Drake into the South Sea, and there hence about the whole Globe of the Earth, begun in the yeere of our Lord 1577." Contained therein, with regard to Nova Albion (now generally accepted by historians to be the vicinity of Drakes Bay, California), are the following two paragraphs:

"Our necessarie busines being ended, our Generall with his companie trauailed vp into the Countrey to their villages, where wee found heardes of Deere by 1000. in a companie, being most large, and fat of bodie.

"We found the whole Countrey to be a warren of a strange kind of Connies, their bodies in bignes as be the Barbarie Connies, their heads as the heads of ours, the feete of a Want, and the taile of a Rat being of great length: vnder her chinne on either side a bagge, into the which she gathereth her meate, when she hath filled her bellie abroad. The people eate their bodies, and make great accompt of their skinnes, for their Kings coate was made of them."

Although the writer has not personally had access to a first edition of Hakluyt (1589) the above quoted lines were checked for accuracy at the Harvard University Library where a copy is available. Grateful acknowledgment is here made for this courtesy extended. H. R. Wagner in "Sir Francis Drake's Voyage Around the World (John Howell, San Francisco, 1926)" expresses the opinion that the "Famous Voyage . . . ," whose authorship is not certainly known but suspected to be either Francis Pretty or Richard Hakluyt himself, was not published until Drake's death in 1596.

The identity of the "strange kind of Connies" might be subject to some doubt in view of its possessing "the taile of a Rat being of great length. . . ." However, such early descriptions were crude and, since comparison is made with the Barbary Cony (presumably of the Order Hyracoidea, the living members of which have only a rudimentary tail) the tail of a pocket gopher might be considered as relatively long.

In any event this seems to be the first published record of what may have been the Botta pocket gopher (*Thomomys bottae bottae*) as well as what was likely the Roosevelt elk (*Cervus canadensis occidentalis*).

Certain of the foregoing facts were called to the writer's attention by Mr. Eric A. Falconer of San Francisco some months before Mr. Grant's article (*op.cit.*) appeared.—ROBERT T. ORR, *California Academy of Sciences, San Francisco 18, California.* *Received October 22, 1949.*

ADDITIONAL RECORDS OF *URSUS CALIFORNICUS*

Our knowledge of the taxonomic characters of *Ursus californicus*, the form of grizzly that once occurred in west-central California according to C. Hart Merriam (N. Amer. Fauna, no. 41, 1918), is based upon a very meager number of specimens most of which are either in the collections of the United States National Museum or the University of Cali-

fornia Museum of Vertebrate Zoology. Grinnell, Dixon, and Linsdale (Fur-bearing mammals of California, vol. 1, p. 68, Univ. Calif. Press, 1937) listed three incomplete specimens of this bear, consisting of a lower jaw and two fragmentary skulls, in the latter institution. Later, Benson (Calif. Fish and Game, 30: 98–100, 1944) recorded the discovery of a tooth in Alameda County, California, that may have belonged to *Ursus californicus*, *U. colusus*, or *U. tularensis*. Barbara Lawrence at the same time (also Calif. Fish and Game 30, p. 98, 1944) described a skull of a grizzly, from California, in the collection of the Harvard Museum of Comparative Zoology. This skull was thought possibly to have come from the vicinity of San Francisco and may represent an additional example of *Ursus californicus*.

In view of the scarcity of relics of this and certain other allied but now extinct kinds of grizzlies in museums the existence of two specimens of *Ursus californicus* in the collection of the California Academy of Sciences, as well as facts relating to their discovery, seem worth recording.

On November 15, 1926, the purchase of a skull and partial skeleton of a grizzly from a Mr. William McGowan was made possible through the assistance of Dr. Harold Heath of Stanford University. In so far as the writer has been able to determine, Mr. McGowan, a retired army sergeant, found the remains buried in about two feet of sand along the shore of Monterey Bay near Marina Post Office, 6 miles northeast of Monterey (the type locality of *Ursus californicus*), California, early in November, 1926. The bones were brought to the Hopkins Marine Station at Pacific Grove and Dr. Heath recognized their value. He contacted the California Academy of Sciences and Dr. G. Dallas Hanna, Curator of Paleontology, went to Mr. McGowan and purchased the skeletal remains for the Academy. These consist of a finely preserved skull and lower jaw, six cervical, ten thoracic, and four lumbar vertebrae, and parts of twenty ribs. The skull and lower jaw are lacking only the first and second upper right premolars, the second upper left premolar, four lower incisors and the last lower right molar. Brief mention of the existence of this specimen was made by Hanna (Bull. Amer. Assoc. Petroleum Geol., 12: 970, 1928.)

This skeleton obviously belonged to an adult bear, judging from the development of the sagittal, temporal, and lambdoidal ridges on the skull. The small size of the skull, however, indicates that the sex of the animal was probably female. The following cranial measurements were made of this specimen which is now number 5567 in the Mammal Collection of the California Academy of Sciences: basal length, 292 mm.; occipito-nasal length, 278 mm.; palatal length, 163 mm.; zygomatic breadth, 173 mm.; interorbital breadth, 76 mm.

On January 25, 1948, Mr. Clifford C. Church, a Research Associate in Paleontology at the California Academy of Sciences, and his son David found a relic of *Ursus californicus* in an Indian mound two and one-half miles southeast of Mayfield, Santa Clara County, California. This was generously presented to the Academy a few days later and is now number 9377 in the Mammal Collection. The specimen consists of most of the left posterior quarter and the majority of the occipital region of the skull. On comparison with the previously described skull from Marina P. O. this partial skull appears to have belonged to a larger bear, although the weakly defined sagittal, temporal, and lambdoidal crests indicate that it was considerably younger and may have been a subadult male.

It is interesting to note that in the University of California Museum of Vertebrate Zoology there is a right mandible of a grizzly, number 16379, that was also collected in an Indian mound near Mayfield in December, 1911. This was recorded by Grinnell, Dixon, and Linsdale (*supra cit.*, p. 68). It is barely possible that these two relics, taken over thirty-six years apart, may have belonged to the same bear.—ROBERT T. ORR, *California Academy of Sciences, San Francisco 18, Calif.* *Received October 22, 1949.*

HARVEST MOUSE IN DANE COUNTY, WISCONSIN

A gravid female harvest mouse with six embryos, 11 mm. C.R., was trapped at the Pheasant Branch marsh October 2, 1949. It has the buffy pectoral spot of the race, *Reithrodontomys megalotis pectoralis*, described by H. C. Hanson (Zool. Series Field Mus. Nat. Hist., 29: 205. Oct. 26, 1944.) This is the first known specimen for the county. In contrast

with the ease with which Hanson took specimens in the southwestern corner of adjoining Columbia County, the above is the only specimen that I have taken during 4500 trap-nights in the western half of Dane County.—A. W. Schorger, *168 N. Prospect Ave., Madison, Wis. Received November 12, 1949.*

A NEW STYLE LIVE-TRAP FOR SMALL MAMMALS

In the course of studying populations of mammals at the University of Kansas Natural History Reservation, the writer and his associates at the Natural History Museum have compared the effectiveness of several types of live-traps, and have experimented to improve upon those available. A new model, tried in different sizes, has proven effective, at least for white-footed mice, harvest mice, house mice, meadow voles, cottonrats, woodrats, and opossums, which are caught regularly with it. Various other types of live-traps currently used by mammalogists are efficient mechanically, and the present model is not claimed to be superior in this regard. Its main virtue lies in its simplicity. This renders its construction easy, rapid, and inexpensive. The inside mechanism is not liable to be tripped from the outside by an animal attempting to dig underneath or climb over the top, as occasionally happens with some other models.

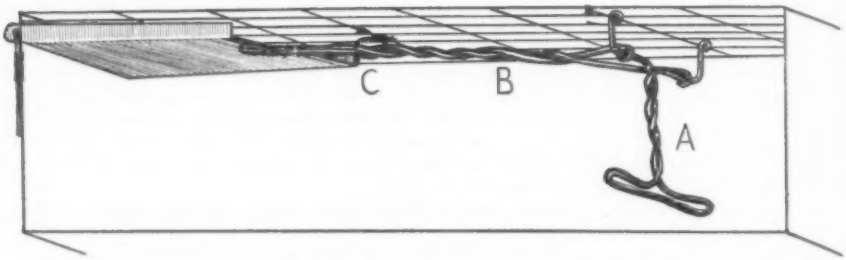

Fig. 1.—Diagrammatic view, inside of trap with left side removed, showing the trigger mechanism, A, suspended from cross-wire of top by its looped ends; piece B pivoting on A, supported anteriorly by wire loop C, and with its anterior tip holding up the door.

The body of the trap is constructed of hardware cloth, or other heavy wire mesh, and is square in cross-section, about 3½ times as long as wide. The door is of heavy sheet metal, and pivots on its upper edge, opening inward, so that when raised it lies along the top of the trap on the inside. The mechanism consists of two pieces of wire. One of these, the trigger (A, see Fig. 1), hangs vertically by the looped ends of its two arms, enclosing on the right and left sides a transverse wire of the top of the trap, on which the trigger pivots, its lower end swinging freely anteriorly or posteriorly in response to any pressure. The lower end of the trigger piece is flanged transversely at an appropriate height above the floor of the trap, so that an animal coming through to reach the bait near the rear end can scarcely avoid touching the trigger and pushing it back. The second wire, B, which holds the door open when the trap is set, lies in a horizontal position a short distance below the roof of the trap, and at the posterior end of this wire two arms diverge laterally, each arm ending in a loop which encloses the horizontal portion of one arm of the trigger, on which this wire (B) pivots. Anteriorly this piece (B) is supported by passing through a loop of light wire (C) attached to the top of the trap. It slides backward and forward through this loop with a piston-like movement, following the pendulum-like swinging of the trigger. To set the trap, it is tilted with the rear end slightly lower, causing the mechanism to swing posteriorly. The door is then raised, and the trap is returned to the horizontal position in which the tip of B slides forward beneath the posterior edge of the door, supporting it. A slight pressure on the trigger from the front side causes it to swing back, carrying B with it, and freeing the door, which drops to the closed position.

The requisite sensitivity is lost if the enclosing loops, on which the parts pivot, are too large, so that there is slack space to be taken up before movement is transmitted from one part to another. The larger animals that are caught frequently escape by raising the door unless a lock mechanism is added. A simple but effective lock is made by drilling a small hole through the upturned edge of the metal door near its bottom; a springy wire is then attached to the side of the trap with the tip bent at right angles, inward, its position adjusted to snap back into the hole in the door when the latter falls shut.

For trapping small rodents, shelters are attached to the ends of the traps; number 10 cans with removable bottoms afford protection from the rain. Heavy cardboard boxes, paraffined and filled with cotton, are placed in the cans for insulation, along with some food. With this protection, even in inclement weather, the trapped rodent usually remains warm, dry, and well fed.—HENRY S. FITCH, *Department of Zoology, University of Kansas, Lawrence.* *Received December 31, 1949.*

REVIEW

Allee, W. C., Alfred E. Emerson, Orlando Park, Thomas Park, and Karl P. Schmidt. PRINCIPLES OF ANIMAL ECOLOGY. Philadelphia and London: W. B. Saunders Company. xii + 837 pp., 263 figs. 1949. $14.00.

The many diverse phases of ecological study pursued by workers with different points of view and with different interests require a unifying synthesis before some, perhaps most, biologists will accept the existence of ecology as a science in its own right. The "Principles of Animal Ecology" is an attempt to achieve such an integration. Unfortunately (and fully recognized by the authors, p. 4) the very title eliminates the field of plant ecology from this unification at the outset, although plants and plant communities are frequently brought into the discussion.

The authors, in the introduction, briefly indicate the scope of the work and the attitudes with which they approach it. The subject is defined, its relationship to other phases of biology is discussed, and the problems and limitations of the work are pointed out.

The first section of the book, dealing with historical background, is especially valuable since no comparable summary with an emphasis on ecological aspects is available. A discussion of the development of ecology before 1900 shows its gradual emergence from the more general biology of previous centuries, first as isolated concepts applicable to certain other areas (e.g., evolution, biogeography, hydrobiology) and finally as self-conscious ecology. A second chapter of the section relates the rapid growth of the science in the present century with the development of the concepts of the community and succession, the interest in animal sociology, the use of quantitative methods, the study of populations, and the practical application of ecology in such fields as game management and fisheries biology. A useful contribution of this section is the list of ecological symposia held between 1930 and 1946 and a subject bibliography of important ecological literature in the 1931–1942 period.

A chapter on the general environment sets a philosophical background for the section on the analysis of the environment. We are well reminded that the fitness (by adaptation) of the organism to the environment is reciprocal. The primary fitness is that of the environment for life; adaptation of organisms to this environment follows. Henderson's argument that the existing environment is the best possible one for life is held to be still valid. The section presents a fuller discussion and classification of environmental factors than appears in most general ecological works. The brevity of the discussion on radiation indicates our particular lack of knowledge of that subject.

Ecological study at the population level has been quite actively pursued for more than twenty years. A documented review by two workers, who have been particularly active in this field, of the techniques and the concepts so far developed is a valuable contribution of the third section of the book. Although much of the material has been previously available, it is now assembled and analyzed from the general ecological viewpoint more completely than heretofore. The demonstration that the population is an integrated unit and, there-

fore, has attributes of its own (e.g., geographic distribution; density) not shared by the individual leads to a better understanding of the more complex unit, the community. The mortality factors which affect populations are classified as density-independent and density-dependent. This classification distinguishes, for the most part, between the physical and the biotic influences of the environment; but it is pointed out (p. 344) by a quotation from H. S. Smith that climatic factors may act in a density-dependent manner, although the mechanism of such action has apparently not yet been satisfactorily demonstrated. However, it seems probable, as Smith suggested, that if welfare factors (such as food and cover) were limited, the degree of decimating action by adverse physical factors would depend to some extent on the density of the population. In such a case the percent of mortality would presumably increase with density. Perhaps such combinations of factors often act in a density-dependent manner where density is reduced at the periphery of ranges.

More evidence is available in regard to the microclimate. It is shown that not only social but also some non-social organisms may, by group action, regulate the temperature of their immediate surroundings to some extent (p. 361–363). Here the density effect is inverse, the percent of mortality decreasing with increasing density. In this case an additional effect is involved; the reaction of the organism actually changes the environment, but the density-dependent concept is still valid since the effect of an external influence (i.e. temperature) depends on the density of the population.

The community has been redefined (p. 436) as ". . . a natural assemblage of organisms which, together with its habitat, has reached a survival level such that it is relatively independent of adjacent assemblages of equal rank; to this extent, given radiant energy, it is self-sustaining." This places restriction on a term that has been used much more loosely, and the authors have, I believe wisely, suggested the retention of both uses since each has valuable applications.

The concept of the community as a complex organism possessing attributes beyond those of the sum of its parts has aroused much controversy. With care, useful analogies can be drawn from such a viewpoint, but some authors have perhaps emphasized too much the similarities at the expense of the differences. In this work the authors point out the values of thinking of the community in terms of a "supra-organism" and list (p. 440) a number of analogies between the cell, the multicellular individual, and the community. They say (p. 435) ". . . we hold that the synthesis growing out of the comparison of organism and supra-organism helps to elucidate fundamental principles and is a challenge leading to further analysis and understanding of biological mechanisms. . . ."

The realization that a species is a population, not an individual, and that evolution often acts upon this population as a unit is one of the basic principles of the "new systematics." The authors have broadened the population concept in relation to evolution to include interspecies units. It is emphasized that selection pressures act upon populations of two or more ecologically related species as a unit thereby evolving the integrated community system. The important coordinating mechanisms of the system are coactions. Thus, it is stated (p. 698), "The evolution of the mechanisms of community integration is largely concerned with the origin of coaction between organisms." Continued evolution of community complexes is supposed to lead to greater perfection of community integration and a resulting greater efficiency in the total ecosystem. Thus the great variety of terrestrial communities and their lesser areal extent as contrasted to marine communities is thought of as indicating the relative youth of the former (p. 235). The greater physical diversity of land habitats seems to the reviewer to be equally or even more important in producing such a situation.

Unfortunately, a considerable number of typographical errors have crept into the book, and scientific nomenclature is not always up to date. The authors have in some cases used outdated names from various works which they cite. Thus, on page 122, *Lutreola vison* is used for the mink with no indication that the accepted name is now *Mustela vison*. Again on page 650 it should have been mentioned that the name of the long-eared owl is now *Asio otus wilsonianus* rather than *Asio wilsonianus*.

The extensive bibliography serves also as an author index; however, workers' names not associated with bibliographic titles are listed in the subject index. Since this requires looking in both indices for a name, a different arrangement might have been preferable. The subject index itself is not consistent; some scientific and common names mentioned in the text are included, while others are not. Numerous cross references to subjects discussed are very helpful. The text is documented quite fully throughout, and references are often given to more nearly complete discussions and to bibliographies of special topics as well as to contrary opinions.

Another step toward a synthesis of the various aspects of ecology is in the reviewer's opinion the most important contribution of the book. In addition it shows the progress of these different aspects to date and points up the areas where gaps in the knowledge are particularly wide. Especially welcome is the extensive treatment of environmental factors. Some standardization of terms may be effected depending on acceptance by other workers. The book should find wide use as a reference source and for collateral reading in ecological courses.

The distribution of the book may be limited by its high cost.—DANA PAUL SNYDER.

RECENT LITERATURE

(Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma M. Charters)

[Reprints of this section may be purchased from the Corresponding Secretary]

AKIYA, SCHIRO. Studies on digestive enzyme in whale. Sci. Repts. Whales Research Inst., Tokyo, no. 1, pp. 3–7, illus. June, 1948.

AKIYA, SCHIRO, YASUTARO ISHIKAWA, SETSUZO TEJIMA, AND TOYOHIKO TANZAWA. Studies on tryptase from a whale (*Balaenoptera borealis* L.). Sci. Repts. Whales Research Inst., Tokyo, no. 1, pp. 8–10. June, 1948.

AKIYA, SCHIRO, SETSUZO TEJIMA, AND YASUTARO ISHIKAWA. Studies on the utilization of whale meat by the use of pancreatic tryptase of whales. Sci. Repts. Whales Research Inst., Tokyo, no. 1, pp. 11–14, illus. June, 1948.

AKIYA, SCHICHIRO, AND KEIICHI TAKAHASHI. Determination of tryptophane in whale meat. Sci. Repts. Whales Research Inst., Tokyo, no. 2, pp. 51–54. December, 1948.

ALLEE, W. C., ALFRED E. EMERSON, ORLANDO PARK, THOMAS PARK, AND KARL P. SCHMIDT. Principles of animal ecology. W. B. Saunders, Philadelphia and London, pp. xii + 837, illus. October, 1949.

ALLEN, DURWARD L. Operation drainpipe. Field & Stream, New York, vol. 54, no. 2, pp. 60, 126–128. June, 1949. (Bounty system)

AMUNDSON, ROD. The muskrat. Wildlife in North Carolina, Raleigh, vol. 13, no. 12, pp. 4–7, illus. December, 1949.

ANDERSON, JACK. Cougar whips bear in bloody battle on Big Creek Forest. Idaho Wildlife Review, Boise, vol. 2, no. 4, p. 13. December, 1949.

ANONYMOUS. Big game winter problems. Oregon State Game Comm. Bull., Portland, vol. 4, no. 2, pp. 1, 3, 10. February, 1949. (Elk and deer)

ANONYMOUS. Wild fur catch decreasing. Texas Game & Fish, Austin, vol. 7, no. 3, p. 11. February, 1949.

ANONYMOUS. Half-breed coyotes on rampage. Kentucky Happy Hunting Ground, Frankfort, vol. 5, no. 2, p. 31, illus. March, 1949.

ANONYMOUS. Values of bounty system. Mississippi Game & Fish, Jackson, vol. 12, no. 9, pp. 13–14. March, 1949.

ANONYMOUS [Interstate Deer Herd Committee]. Interstate winter deer range management plan. California Fish & Game, Berkeley, vol. 35, no. 2, pp. 103–114, illus. April, 1949. (California and Oregon)

ANONYMOUS [Interstate Deer Herd Committee]. Third progress report on the cooperative study of the interstate deer herd and its range. California Fish & Game, Berkeley, vol. 35, no. 2, pp. 115–134, illus. April, 1949.

ANONYMOUS. Utah deer loss heavy despite emergency feeding program. Utah Fish & Game Bull., Salt Lake City, vol. 7, no. 3, pp. 1, 3–6, illus. April, 1949.

ANONYMOUS. The 1949 elk census. Wyoming Wild Life, Cheyenne, vol. 13, no. 4, pp. 23–24, illus. May, 1949.

ANONYMOUS. Somnolent sea-lion. Illus. London News, vol. 215, no. 5760, p. 395, illus. September 10, 1949. (Photo of California sea lion)

ANONYMOUS. At Edinburgh University: the Royal College of Surgeons' Anatomical Museum. Illus. London News, vol. 215, no. 5765, p. 586, illus. October 15, 1949.

AUB, JOSEPH C., GEORGE B. WISLOCKI, AND CHARLES M. WALDO. The growth of the deer antler. New York State Conservationist, Albany, vol. 4, no. 3, pp. 4–5, illus. December, 1949–January, 1950.

BABAULT, G. Notes éthologiques sur quelques mammifères africains. Generalities sur les artiodactyles ruminants des savanes. Mammalia, Paris, vol. 13, no. 3, pp. 57–68. September, 1949.

BACHMAN, ELIZABETH. The ramblin' 'rat' covers the continent. South Dakota Conservation Digest, Pierre, vol. 16, no. 12, pp. 1, 14. December, 1949. (Muskrat)

BARGER, N. R. Mearn's cottontail (*Sylvilagus floridanus mearnsi*). Wisconsin Conservation Bull., Madison, vol. 14, no. 9, pp. 31–32, illus. September, 1949.

BASSETT, CHARLES F., AND LEONARD M. LLEWELLYN. The molting and fur growth pattern in adult mink. Amer. Fur Breeder, Duluth, vol. 22, no. 9, pp. 8–13, illus. March, 1950.

BATE, DOROTHEA M. A. A new African fossil long-horned buffalo. Ann. & Mag. Nat. Hist., London, ser. 12, vol. 2, no. 17, pp. 396–398. August 19, 1949. (New: *Homoioceras*, *H. singae*)

BAUDENON, P. Contribution à la connaissance du potto de Bosman dans le Togo-Sud. Mammalia, Paris, vol. 13, no. 3, pp. 76–99. September, 1949.

BEMMEL, A. C. V. VAN. A further note on Axis (Hyelaphus) kuhlii (Müller & Schlegel) (Ungulata, Cervidae). Treubia, Buitenzorg, vol. 19, pt. 2, pp. 403–406. May, 1948.

BEMMEL, A. C. V. VAN. A note on Phalanger atrimaculatus Tate (Mammalia, Marsupialia). Treubia, Buitenzorg, vol. 20, pt. 1, pp. 55–56. October, 1949.

BEMMEL, A. C. V. VAN. Revision of the rusine deer in the Indo-Australian Archipelago. Treubia, Buitenzorg, vol. 20, pt. 2, pp. 191–262, pls. 2–4. October, 1949. (New: *Rusa timorensis laronesiotes*, *R. t. djonga*)

BEMMEL, A. C. V. VAN. A note on Lutrogale perspicillata (I. Geoffroy) (Mustelidae). Treubia, Buitenzorg, vol. 20, pt. 2, pp. 375–377. October, 1949.

BEMMEL, A. C. V. VAN. On the meaning of the name Cervus javanicus Osbeck 1765 (Tragulidae). Treubia, Buitenzorg, vol. 20, pt. 2, pp. 378–380. October, 1949.

BERNER, LESTER M. Our big game harvest in 1948. South Dakota Conservation Digest, Pierre, vol. 16, no. 2, pp. 10, 14, 16. February, 1949.

BERRYMAN, JACK H. Facts of interest about Utah mammals. VI. Order Carnivora, family Mustelidae. Utah Fish & Game Bull., Salt Lake City, vol. 7, no. 1, pp. 6–8, illus. January–February, 1949. (Mink, otter)

BERRYMAN, JACK H. Facts of interest about Utah mammals. VII. Family Mustelidae. Utah Fish & Game Bull., Salt Lake City, vol. 7, no. 2, pp. 3–4, illus. March, 1949.

BERRYMAN, JACK H. Facts of interest about Utah mammals. VIII. Taxidea taxus—badger. Utah Fish & Game Bull., Salt Lake City, vol. 7, no. 3, p. 3. April, 1949.

BERSING, OTIS S. The hunter's opinion of an any deer season. Wisconsin Conservation Bull., Madison, vol. 14, no. 9, pp. 6–9, illus. September, 1949.

BROCKLEY, HARRY J. Antelope in the snow. Wyoming Wildlife, Cheyenne, vol. 13, no. 4, pp. 27–30, illus. May, 1949.

Broom, R., and J. T. Robinson. A new type of fossil baboon, Gorgopithecus major. Proc. Zool. Soc. London, vol. 119, pt. 2, pp. 379–386, figs. 7, pl. 1. August 17, 1949. (New: *Gorgopithecus*, type, *Parapapio major* Broom)

Brouwer, G. A. Enige historische bijzonderheden over het edelhert in Nederland en een beschouwing over de veluwse herten als natuurbeschermingsobject. *In* "In het voetspoor van Thijsse," H. Veenman & Sons, Wageningen, pp. 214–248, figs. 12. 1949.

Brown, Roland W., and William T. Pecora. Paleocene and Eocene strata in the Bearpaw Mountains, Montana. Science, Lancaster, vol. 109, no. 2837, pp. 487–488. May 13, 1949. (*Homogalax, Echippus, Coryphodon, Diacodexis.*)

Burr, J. G. Wildlife thrives in Big Bend area. Texas Game & Fish, Austin, vol. 7, no. 6, pp. 4–5, 20–22, illus. May, 1949.

Burt, William H. Present distribution and affinities of Mexican mammals. Annals Assoc. Amer. Geographers, vol. 39, no. 3, pp. 211–218. September, 1949.

Burton, Maurice. Rodents carve their way to success. Illus. London News, vol. 215, no. 5765, p. 592, illus. October 15, 1949.

Buxton, P. A. Experiments with mice and fleas. I. The baby mouse. Parasitology, Cambridge, vol. 39, nos. 1–2, pp. 119–124. July, 1948.

Cantuel, P. Préparation rapide de pièces ostéologiques. Mammalia, Paris, vol. 13, no. 3, pp. 100–103. September, 1949.

Chase, Greenleaf T. New York's coyote control problem. New York State Conservationist, Albany, vol. 4, no. 3, pp. 14–15, illus. December, 1949–January, 1950.

Clark, George. The failure of estrogen to induce changes in the sex skin of the male chimpanzee. Yale Jour. Biol. Med., New Haven, vol. 21, no. 3, pp. 245–247. January, 1949.

Colbert, James W. Review of animal experimentation in infectious hepatitis and serum hepatitis. Yale Jour. Biol. Med., New Haven, vol. 21, no. 4, pp. 335–343. March, 1949.

Cook, Arthur H. The fisher. New York State Conservationist, Albany, vol. 4, no. 3, p. 24, illus. December, 1949–January, 1950.

Cordier, Charles. I'll bring back a bongo yet. American Mag., Springfield, vol. 148, no. 5, pp. 42–43, 86–90, illus. November, 1949. (Photos bongo, giant pangolin, aard vark.)

Craigie, E. Horne. Practical anatomy of the rabbit. Blakiston, Philadelphia, pp. xii + 391, illus. 1948.

Cross, R. H., Jr. Squirrels in September? Virginia Wildlife, Richmond, vol. 10, no. 9, pp. 8–9, illus. September, 1949. (Problems of early season hunting.)

Davis, David E. An animal's home is its castle. Sci. Monthly, Lancaster, vol. 69, no. 4, pp. 249–253. October, 1949. (Territorialism)

Dell, Joseph. Snowshoe rabbits. New York State Conservationist, Albany, vol. 3, no. 4, p. 29, illus. February–March, 1949.

Dunbar, M. J. The Pinnipedia of the Arctic and Subarctic. Bull. Fisheries Research Board Canada, Ottawa, no. 85, pp. 22. 1949.

Edson, Marshall. Antelope transplanting project on Lost River and Birch Creek ranges removes 298 pronghorns. Idaho Wildlife Rev., Boise, vol. 2, no. 4, pp. 8–9, illus. December, 1949.

Ellerman, J. R. On the prior name for the Siberian lemming and the genotype of *Glis* Erxleben. Ann. & Mag. Nat. Hist., London, ser. 12, vol. 2, no. 23, pp. 893–894. November 11, 1949.

Fitz, Grancel. We flew back 20,000 years. Field and Stream, New York, vol. 54, no. 1, pp. 46–47, 142–145, illus. May, 1949. (Barren Ground caribou)

Fleay, David. Australia's yellow-footed marsupial mouse. Animal Kingdom, New York, vol. 53, no. 1, pp. 20–24, illus. January–February, 1950.

Fletcher, H. O. "Thar she blows:" whaling in Antarctic seas. Australian Mus. Mag., Sydney, vol. 9, no. 12, pp. 393–397, illus. September 30, 1949.

Fox, Wade. Variation in the deer-mouse (*Peromyscus maniculatus*) along the Lower Columbia River. Amer. Midland Nat., Notre Dame, vol. 40, no. 2, pp. 420–452, figs. 2. September, 1948.

Gaufin, D. M., and Harold S. Crane. Digest of 1948 big game kill. Utah Fish & Game Bull., Salt Lake City, vol. 8, no. 4, pp. 1–2. May, 1949.

Green, Hubert U. Occurrence of Echinococcus granulosus in elk (Cervus canadensis nelsoni), Banff National Park. Canadian Field Nat., Ottawa, vol. 63, no. 5, pp. 204–205. October 25, 1949.

Gruet, M., and Y. Dufour. Étude sur les chauves-souris troglodytes du Maine-et-Loire. Mammalia, Paris, vol. 13, no. 3, pp. 69–75. September, 1949.

Guenther, Stanley, E. Nutria. Washington State Game Bull., Seattle, vol. 2, no. 1, p. 5, illus. 1950. (Introduction, capture of feral animals)

Guilday, John E. Winter food of Pennsylvania mink. Pennsylvania Game News, Harrisburg, vol. 20, no. 9, pp. 12, 32. December, 1949.

Gunston, David. A vanishing race? Mag. of the Future, London, vol. 4, no. 6, pp. 52–57, illus. January, 1950. (Whaling industry)

Hall, E. Raymond. [Review of] Ecology of the California ground squirrel on grazing lands, by Henry S. Fitch. Ecology, Brooklyn, vol. 30, no. 1, p. 112. January, 1949.

Hall, E. Raymond, and Walter W. Dalquest. Geographic range of the hooded skunk, Mephitis macroura, with description of a new subspecies from Mexico. Univ. Kansas Publ., Mus. Nat. Hist., Lawrence, vol. 1, no. 24, pp. 575–580, fig. 1. January 20, 1950. (New: *Mephitis macroura eximius*)

Hall, E. Raymond, and Walter W. Dalquest. Pipistrellus cinnamomeus Miller 1902 referred to the genus Myotis. Univ. Kansas Publ., Mus. Nat. Hist., Lawrence, vol. 1, no. 25, pp. 581–590, figs. 5. January 20, 1950.

Hall, E. Raymond, and Walter W. Dalquest. A synopsis of the American bats of the genus Pipistrellus. Univ. Kansas Publ., Mus. Nat. Hist., Lawrence, vol. 1, no. 26, pp. 591–602, fig. 1. January 20, 1950.

Hamilton, W. J., Jr. Chipmunk. New York State Conservationist, Albany, vol. 4, no. 1, p. 14, illus. August-September, 1949.

Hamly, D. H. Robert Ridgway's color standards. Science, Lancaster, vol. 109, no. 2842, pp. 605–608. June 17, 1949.

Hargrave, Charles W. The 1949 aerial muskrat survey. North Dakota Outdoors, Bismarck, vol. 12, no. 6, p. 12, illus. December, 1949.

Harned, B. K., Raymond W. Cunningham, and Edna R. Gill. A metabolism cage for small animals. Science, Lancaster, vol. 109, no. 2837, pp. 489–490, illus. May 13, 1949.

Harrison, D. L., and D. V. Davies. A note on some epithelial structures in Microchiroptera. Proc. Zool. Soc. London, vol. 119, pt. 2, pp. 351–357, pl. 1. August 17, 1949.

Harrison, R. G. The comparative anatomy of the blood-supply of the mammalian testis. Proc. Zool. Soc. London, vol. 119, pt. 2, pp. 325–344, figs. 4, pls. 5. August 17, 1949.

Hescheler, Karl, and Emil Kuhn. Die Tierweld der prähistorischen Siedelungen der Schweiz. *In* Otto Tschumi, Urgeschichte der Schweiz, Huber & Co., Frauenfeld, vol. 1, pp. 121–368, figs. 38–146. 1949.

Hewer, T. F., L. Harrison Matthews, and T. Malkin. Lipuria in tigers. Proc. Zool. Soc. London, vol. 118, pt. 4, pp. 924–928. February 28, 1949.

Hill, W C. Osman, and L. Harrison Matthews. The male external genitalia of the gorilla, with remarks on the os penis of other Hominoidea. Proc. Zool. Soc. London, vol. 119, pt. 2, pp. 363–378, figs. 6, pls. 4. August 17, 1949.

Hitchcock, Harold B. Myotis lucifugus lucifugus mistaken for Myotis keeni septentrionalis. Canadian Field Nat., Ottawa, vol. 63, no. 5, p. 209. October 25, 1949.

Hodge, Walter Henricks. Llamas: New World beasts of burden. Illus. London News, vol. 215, no. 5769, pp. 752–753, illus. November 12, 1949.

HOFFMEISTER, DONALD F. A concentration of lemming mice (Synaptomys cooperi) in central Illinois. Trans. Illinois Acad. Sci., Springfield, vol. 40, pp. 190–193, fig. 1. 1947.

HOFFMEISTER, DONALD F. [Review of] Wild mammals of Virginia, by Charles O. Handley, Jr., and Clyde P. Patton. Jour. Wildlife Management, Menasha, vol. 12, no. 3, pp. 335–336. July, 1948.

HOFFMEISTER, DONALD F. The wolves and coyotes of Illinois. Illinois Wildlife, vol. 4, no. 2, pp. 4–5, illus. March, 1949.

HOFFMEISTER, DONALD F. A new name for the meadow mouse Microtus roberti occidentalis Turov. Jour. Washington Acad. Sci., vol. 39, no. 6, pp. 205–206. June 15, 1949. (New: *Microtus roberti turovi*)

HOLWEG, ARTHUR W. Deer kill, season of 1948. New York State Conservationist, Albany, vol. 3, no. 4, pp. 24–25, 33. February–March, 1949.

HOOPER, EMMET T. A new subspecies of harvest mouse (Reithrodontomys) from Central America. Proc. Biol. Soc. Washington, vol. 62, pp. 169–172. November 16, 1949. (New: *Reithrodontomys mexicanus orinus*)

HOPKINS, G. H. E. The host-associations of the lice of mammals. Proc. Zool. Soc. London, vol. 119, pt. 2, pp. 387–604. August 17, 1949.

HOSLEY, NEIL W. History of big game in the United States. Internat. Tech. Conf. on Protection Nature, UNESCO, IUPN, Conf. 2, Misc. 23, Lake Success, pp. 6 (mimeographed). August, 1949.

HOSLEY, N. W. The moose and its ecology. Wildlife Leaflet U. S. Fish & Wildlife Service, Washington, no. 312, pp. 51, figs. 10. October, 1949.

HUEY, LAURENCE M. Three new races of pocket gophers (Thomomys) from Baja California, Mexico. Trans. San Diego Soc. Nat. Hist., vol. 11, no. 4, pp. 53–56. January 31, 1949. (New: *Thomomys bottae ruricola, T. b. rhizophagus, T. b. homorus*)

HUTCHINSON, G. EVELYN. Lemmings and lynxes. Amer. Scientist, Burlington, vol. 37, no. 4, pp. 614, 616, 618. October, 1949.

INGLES, LLOYD G. Field observations on the growth of young mountain pocket gophers. Murrelet, Seattle, vol. 30, no. 2, pp. 35–36. May–August, 1949.

ISHIKAWA, SEIICHI, YOSHIMORI OMOTE, AND YOSHITAKA SOMA. Analytical distillation of vitamin A in the whale liver oil. Sci. Repts. Whales Research Inst., Tokyo, no. 2, pp. 35–41, figs. 5. December, 1948.

ISHIKAWA, SEIICHI, YOSHIMORI OMOTE, AND HIDEO KANNO. Molecular distillation of sperm whale blubber oil. Sci. Repts. Whales Research Inst., Tokyo, no. 2, pp. 42–45, figs. 2. December, 1948.

ISHIKAWA, YASUTARO, AND SETSUZO TEJIMA. Protein digestive power of sperm whale pancreatic enzyme. Sci. Repts. Whales Research Inst., Tokyo, no. 2, pp. 55–60, illus. December, 1948.

JEPSEN, GLENN L. Selection, "orthogenesis" and the fossil record. Proc. Amer. Philos. Soc., Philadelphia, vol. 93, no. 6, pp. 479–500. December, 1949.

JEPSEN GLENN L., GEORGE GAYLORD SIMPSON, AND ERNST MAYR [editors]. Genetics, paleontology and evolution. Princeton Univ. Press, pp. xiv + 474, illus. 1949.

JEPSEN, GLENN LOWELL. Memorial to William Berryman Scott. Proc. Vol. Geol. Soc. America, Ann. Report 1948, pp. 211–228, pl. 15. April, 1949.

JONES, FREDERIC WOOD. The study of a generalized marsupial (*Dasycercus cristicauda* Krefft). Trans. Zool. Soc. London, vol. 26, pt. 5, pp. 409–501, figs. 99, pls. 2. November, 1949.

KALELA, OLAVI. Changes in the distribution of the polecat in Finland. Suomen Riista, Helsinki, vol. 2, pp. 77–96, 4 figs., 3 maps. 1948. (Finnish, with English summary)

KALELA, OLAVI. Über Fjeldlemming-Invasionen und andere irreguläre Tierwanderungen, mit einer Übersicht der Kleinnagergradationen in Finnisch-Lappland 1900–1948. Ann. Zool. Soc. Fennicae, Helsinki, vol. 13, no. 5, pp. iv + 90, 5 figs., 10 maps. 1949. (With English summary)

KANEKO, AIJI. Molecular distillation of fin whale liver oil. Sci. Repts. Whales Research Inst., Tokyo, no. 2, pp. 46–50. December, 1948.

KEITH, ARTHUR. A new theory of human evolution. Philosophical Library, New York, pp. x + 451. 1949.

KELSON, KEITH R. Two new wood rats from eastern Utah. Jour. Washington Acad. Sci., vol. 39, no. 12, pp. 417–419. December 15, 1949. (New: *Neotoma cinerea macrodon*, *N. lepida sanrafaeli*)

KÜHNE, WALTER G. On a triconodont tooth of a new pattern from a fissure-filling in South Glamorgan. Proc. Zool. Soc. London, vol. 119, pt. 2, pp. 345–350, figs. 2. August 17, 1949. (New: *Morganucodon watsoni*)

KURODA, NAGAMICHI. The occurrence of the spinous rat in Okinawa Island in the central Riu Kiu Islands. Bull. Biogeogr. Soc. Japan, Tokyo, vol. 13, no. 9, pp. 59–64, pl. 2. April, 1943. (In Japanese, with English summary; a new generic name, *Tokudaia*.)

LATHAM ROGER M. Facts for deer hunters. Pennsylvania Game News, Harrisburg, vol. 20, no. 8, pp. 4–6, 28–29, illus. November, 1949.

LAUCKHART, BURTON. Deer management in Washington. Washington State Game Bull., Seattle, vol. 1, no. 1, pp. 1–4, illus. August, 1949.

LEOPOLD, A. STARKER. On time and survival. Pacific Discovery, California Acad. Sci., San Francisco, vol. 1, no. 6, pp. 28–29. November–December, 1948.

MACE, R. V. 1948 deer and elk kills. Oregon State Game Comm. Bull., Portland, vol. 4, no. 5, pp. 1, 4–7, illus. May, 1949.

MARPLES, B. J. Two endocranial casts of cetaceans from the Oligocene of New Zealand. Amer. Jour. Sci., New Haven, vol. 247, pp. 462–471, figs. 3. July, 1949.

MATHESON, COLIN. History of the lynx. Jour. Soc. Preserv. Fauna Empire, Hertford, pt. 58, pp. 18–27, December, 1947.

MATTHEWS, L. HARRISON. Whales. Proc. Royal Philos. Soc. Glasgow, 147th sess., 1948–1949, vol. 73, pt. 1, pp. 1–13, illus. 1948.

MATTHEWS, L. HARRISON. Cyclic changes in the uterine mucosa of balaenopterid whales. Jour. Anat., Cambridge, vol. 82, pt. 3, pp. 207–232, figs. 4, pls. 4. October, 1948.

MATTHEWS, L. HARRISON, AND R. J. HARRISON. Subsurface crypts, oogensis, and the corpus luteum in the ovaries of seals. Nature, London, vol. 164, no. 4170, pp. 587–588. October 1, 1949.

MAYER, JEAN. Gross efficiency of growth of the rat as a simple mathematical function of time. Yale Jour. Biol. Med., New Haven, vol. 21, no. 5, pp. 415–419. May, 1949.

MILLER, LOWELL S., AND DONALD F. HOFFMEISTER. [Review of] The mammals of Virginia, by John Wendell Bailey. Jour. Wildlife Management, Menasha, vol. 12, no. 2, pp. 217–218. April, 1948.

MILLER, ROLAND B. Where's the beaver? New York State Conservationist, Albany, vol. 3, no. 5, p. 35, illus. April–May, 1949.

MOHR, ERNA. Einiges vom grossen und vom kleinen Mara (*Dolichotis patagonum* Zimm. und *salinicola* Burm.) Zool. Garten, Leipzig, N. F., vol. 16, nos. 3–4, pp. 111–133, figs. 50. 1949.

MOORE, JOSEPH CURTIS. Range extensions of two bats in Florida. Quart. Jour. Florida Acad. Sci., vol. 11, no. 1, p. 50. March 22, 1949.

MOORE, JOSEPH CURTIS. Notes on the shrew, Sorex cinereus, in the southern Appalachians. Ecology, Brooklyn, vol. 30, no. 2, pp. 234–237. April, 1949.

MORRIS, R. F. Differentiation by small mammal predators between sound and empty cocoons of the European spruce sawfly. Canadian Entomologist, Ottawa, vol. 81, no. 5, pp. 114–120, illus. May, 1949.

MOYNAHAN, JAMES O. The beaver is staging a comeback. Kentucky Happy Hunting Ground, Frankfort, vol. 5, no. 5, pp. 5, 29, illus. September, 1949.

NAKAI, JUNNOSUKE, AND TOSHITOMO SHIDA. Sinus-hairs of the seiwhale (Balaenoptera borealis). Sci. Rept. Whales Research Inst., Tokyo, no. 1, pp. 41–47. June, 1948.

NAKAI, TADASHI. Chemical studies on the freshness of whale meat. I, II, III. Sci. Rept. Whales Research Inst., Tokyo, no. 1, pp. 17–26, 27–30; no. 2, pp. 31–34, illus. June, December, 1948.

OGAWA, TEIZO, AND SHOZO ARIFUKU. On the acoustic system in cetacean brains. Sci. Repts. Whales Research Inst., Tokyo, no. 2, pp. 1–20, figs. 14. December, 1948.

PACKARD, EARL LEROY. Fossil baleen from the Pliocene of Cape Blanco, Oregon. Oregon State Monographs, Studies in Geol., Corvallis, no. 5, pp. 1–8, pl. 1. December, 1947.

PACKARD, EARL LEROY. A fossil sea lion from Cape Blanco, Oregon. Oregon State Monographs, Studies in Geol., Corvallis, no. 5, pp. 15–19, pl. 2. December, 1947.

PACKARD, EARL LEROY. A pinniped humerus from the Astoria Miocene of Oregon. Oregon State Monographs, Studies in Geol., Corvallis, no. 5, pp. 25–28, pl. 3. December, 1947.

PEARSON, OLIVER P. Reproduction of a South American rodent, the mountain viscacha. Amer. Jour. Anat., Philadelphia, vol. 84, no. 1, pp. 143–174, figs. 3, pls. 3. January, 1949.

PIKE, GALEN W. Food for deer and food for thought. Wisconsin Conservation Bull., Madison, vol. 14, no. 7, pp. 22–24. July, 1949.

PIKE, OLIVER G. Scenes in the life of an otter. Illus. London News, vol. 215, no. 5764, p. 554, illus. October 8, 1949.

PIKE, OLIVER G. Where wild creatures lose their fear of man: a small nature reserve in a private garden. Illus. London News, vol. 215, no. 5766, pp. 614–615, illus. October 22, 1949. (Fox, badger, rabbit, otter)

RAND, A. L. Mammals of the Eastern Rockies and Western Plains of Canada. Nat. Mus. Canada Bull., no. 108 (Biol. Ser. no. 35), Ottawa, pp. vii + 237, figs. 88. 1948.

RESNER, O. L. Control of big game depredations on agriculture. Washington State Game Bull., Seattle, vol. 1, no. 1, pp. 5–6, illus. August, 1949.

RHOAD, A. O. The Santa Gertrudis breed. The genesis and the genetics of a new breed of beef cattle. Jour. Heredity, Washington, vol. 40, no. 5, pp. 114–126, figs. 8. May, 1949.

RIESS, B. F., SHERMAN ROSS, S. B. LYERLY, AND H. B. BIRCH. The behavior of two captive specimens of the lowland gorilla, *Gorilla gorilla gorilla* (Savage & Wyman). Zoologica, New York Zool. Soc., vol. 34, pt. 3, no. 13, pp. 111–118, pls. 1–2. November 30, 1949.

RUSCONI, CARLOS. El Puelchense de Buenos Aires y su fauna (Plioceno Medio) (primera parte). Publ. Inst. Fisiografia y Geologia, Univ. Nacional del Litoral, Rosario, no. 33, pp. 1–99. 1948. (New: *Scelidotherium parodii puelchense*, *Macrocavia parca*.)

RUSCONI, CARLOS. El Puelchense de Buenos Aires y su fauna (Plioceno Medio) (segunda parte). Publ. Inst. Fisiografia y Geologia, Univ. Nacional del Litoral, Rosario, no. 34, pp. 100–242, pls. 1–17. 1949. (New: *Xenohydrochoerus gracilis*, *Trigodon gaudryi quadratus*, *Onohippidium compressidens magnum*, *Zaëdyus praecursor*)

SCHANTZ, VIOLA S. A new race of badger (Taxidea) from Kansas. Jour. Washington Acad. Sci., vol. 40, no. 3, pp. 92–93. March 15, 1950. (New: *Taxidea taxus merriami*)

SCHICK, ARMIN F., AND GEORGE M. HASS. A new method for isolation and purification of mammalian striated myofibrils. Science, Lancaster, vol. 109, no. 2837, pp. 486–487, illus. May 13, 1949.

SCHMALHAUSEN, I. I. Factors of evolution. Translated by Isadore Dordick and edited by Theodosius Dobzhansky. Blakiston, Philadelphia, pp. xiv + 427, illus. 1949.

SCHWARTZ, CHARLES W., AND ELIZABETH REEDER SCHWARTZ. A reconnaissance of the game birds of Hawaii. Board Comm. Agric. & Forestry, Div. Fish & Game, Terr. Hawaii, pp. 168, illus., 9 maps. 1949. (Mammalian predators, pp. 137–140)

SCHWARZ, ERNST. The northern limit of the fauna of the African equatorial forest. Science, Lancaster, vol. 110, no. 2848, p. 124. July 29, 1949.

SEAGERS, CLAYT. The coyote—unbidden guest. New York State Conservationist, Albany, vol. 3, no. 5, pp. 40–41, illus. April–May, 1949.

SEAGERS, CLAYT. The red squirrel. New York State Conservationist, Albany, vol. 4, no. 3, pp. 40–44, illus. December, 1949–January, 1950.

SETZER, HENRY W. Subspeciation in the kangaroo rat, Dipodomys ordii. Univ. Kansas Publ., Mus. Nat. Hist., Lawrence, vol. 1, no. 23, pp. 473–573, figs. 27. December 27, 1949. (New: *Dipodomys ordii medius, D. o. extractus, D. o. idoneus, D. o. fuscus*)

SLIJPER, E. J. On some phenomena concerning pregnancy and parturition of the Cetacea. Bijdragen tot de Dierkunde, Leiden, vol. 28, pp. 416–448, pls. 21–25. 1949.

SOPER, J. DEWEY. Notes on the fauna of the former Nemiskam National Park and vicinity, Alberta. Canadian Field Nat., Ottawa, vol. 63, no. 5, pp. 167–182, figs. 4. October 25, 1949.

SORSBY, ARNOLD. A clinical report on the eye of the tarsier. Proc. Zool. Soc. London, vol. 119, pt. 2, pp. 359–361, pl. 1. August 17, 1949.

STEINER, HANS. Beobachtungen über das brutbiologische Verhalten des Gibbons und an einem frühgeborenen Fötus bei einer Bastardzucht von *Hylobates*. Archiv. Julius Klaus-Stiftung Vererbungsforschung, Sozialanthropologie und Rassenhygiene, Zurich, vol. 24, pp. 217–236, figs. 6, pls. 2. 1949.

STOLLBERG, B. P. Deer starve at feeding stations. Wisconsin Conservation Bull., Madison, vol. 14, no. 2, pp. 18–19, illus. February, 1949.

STORER, TRACY I. Control of field rodents in California. Circular California Agr. Extension Service, Univ. California, Berkeley, no. 138, pp. 50, illus. Revised, November, 1949.

STRAUS, WILLIAM L., JR. The riddle of man's ancestry. Quart. Rev. Biol., Baltimore, vol. 24, no. 3, pp. 200–223, figs. 8. September, 1949.

STUEWER, F. W. Does are deer, too! Michigan Conservation, Lansing, vol. 18, no. 6, pp. 8–11. December, 1949.

SWANSON, P. W. Live-trapping of marten. Sylva, Toronto, vol. 5, no. 6, pp. 10–14, illus. November–December, 1949.

SWYNNERTON, G. H. On the type locality of *Tragelaphus scriptus reidæ* Babault. Ann. & Mag. Nat. Hist., London, ser. 12, vol. 2, no. 14, pp. 156–157. June 17, 1949.

SYLVESTER, WALTER R. The story of a Portage County deer yard. Wisconsin Conservation Bull., Madison, vol. 14, no. 5, pp. 13–16, illus. May, 1949.

TALIAFERRO, WILLIAM H., AND LUCY GRAVES TALIAFERRO. A sexual reproduction of Plasmodium knowlesi in rhesus monkeys. Jour. Inf. Disease, Chicago, vol. 85, no. 2, pp. 107–125. September–October, 1949.

TAWARA, TADASHI. On the simultaneous extraction of vitamin A-D and vitamin B_2 complex from the liver of a fin whale (Nagasu-kujira, *Balaenoptera physalus* L). Sci. Repts. Whales Research Inst., Tokyo, no. 1, pp. 31–37. June, 1948.

TAWARA, TADASHI. Studies on whale blood. I. Sci. Repts. Whales Research Inst., Tokyo, no. 1, pp. 38–40. June, 1948.

TAYLOR, A. CECIL. Microscopic observation of the living tooth pulp. Science, Lancaster, vol. 111, no. 2872, pp. 40. January 13, 1950.

TRAVIS, H. F., R. E. HOWELL, A. C. GROSCHKE, AND C. G. CARD. Mink feeding experiments: Report I. Quart. Bull. Michigan Agric. Exp. Sta., East Lansing, vol. 32, no. 1, pp. 64–69. August, 1949.

TSUKAMOTO, SABURO. Experiment on digestion of whale meat by Koji-mould. Sci. Repts. Whales Research Inst., Tokyo, no. 2, pp. 61–66. December, 1948.

UHLIG, HANS. G. Squirrels hold first place. West Virginia Conservation, Charleston, vol. 12, no. 11, p. 9. February, 1949. (Squirrel hunting)

URSIN, ERIK. Variation in number of enamel loops in the two anterior upper cheek-teeth in Danish *Microtus agrestis* (L). Vidensk. Medd. fra Dansk naturh. Foren., København, vol. 111, pp. 257–261, figs. 2. November 5, 1949.

VAN LIERE, EDWARD J., J. CLIFFORD STICKNEY, AND DAVID F. MARSH. Sex differences in blood pressure of dogs. Science, Lancaster, vol. 109, no. 2837, p. 489. May, 1949.

VERSCHUREN, JACQUES. L'Activite et les desplacements hivernaux des cheiropteres en Belgique. Bull. Inst. Royal Sci. Nat. Belgique, vol. 25, no. 3, pp. 1–7. January, 1949.

WALKER, ERNEST P. Bats are my best friends. Saturday Evening Post, Philadelphia, vol. 222, no. 32, pp. 26–27, 97–98, illus. February 4, 1950.

WHITLOCK, S. C. Disease in Michigan deer. Michigan Conservation, Lansing, vol. 18, no. 6, pp. 33–34. December, 1949.

WILLIAMSON, KENNETH. Notes on the caaing whale. Scottish Naturalist, Edinburgh, vol. 61, no. 2, pp. 68–72, pls. 4–5. Summer, 1949.

WILLOUGHBY, DAVID P. The gorilla—largest living primate. Sci. Monthly, Lancaster, vol. 70, no. 1, pp. 48–57, figs. 7. January, 1950.

WILSON, KEN. Muskrat management in the Northwest River Marsh. Wildlife in North Carolina, Raleigh, vol. 13, no. 6, pp. 14–16, illus. June, 1949.

WOERPEL, LESLIE. Too late to save central area deer? Wisconsin Conservation Bull., Madison, vol. 14, no. 3, p. 30. March, 1949.

WOLF, BILL. Mutiny on the bounties. Louisiana Conservationist, New Orleans, vol. 1, no. 8, pp. 14–15, 23–24, illus. April, 1949.

WOOD, ALBERT E. A new Oligocene rodent genus from Patagonia. Amer. Mus. Novitates, New York, no. 1435, pp. 54, figs. 8. November 18, 1949. (New: Family *Acaremyidae; Platypittamys, P. brachydon*)

YAMADA, MUNESATO. Auditory organ of the whalebone whales. Sci. Repts. Whales Research Inst., Tokyo, no. 2, pp. 21–30, figs. 7. December, 1948.

OBITUARY NOTICES

DR. WILLIAM BONAR BELL

(1877–1949)

Dr. William Bonar Bell was born at Milton, Iowa, June 2, 1877. He was educated at Iowa State Teachers' College, and at the University of Iowa where he received his Master's degree in 1903 and a Ph.D in 1905. After graduation he joined the faculty of the North Dakota Agricultural College where he remained until 1916. Shortly thereafter he entered government service, but in the interim he carried on research in Naples, Italy, for a short time.

A veteran employee of the U. S. Fish and Wildlife Service (formerly the Biological Survey and the Bureau of Fisheries), Doctor Bell was associated with this field for 28 years. He retired on July 31, 1944, and on March 30, 1949, was stricken suddenly with heart disease.

Upon entering the Bureau of Biological Survey in 1916, Doctor Bell served as chief assistant to the late Dr. A. K. Fisher in the administration of compaigns for the control of noxious rodents and predatory animals. In 1927 Doctor Bell was appointed in charge of the Division of Biological Investigations. In 1935 the Bureau of Biological Survey was reorganized during the administration of J. N. Darling, and the research units were consolidated into a new Division of Wildlife Research. Doctor Bell was placed in charge of this enlarged scientific division. It was during his tenure as chief of this Division that wildlife research field stations were set up on public lands and research units were established in co-operation with a number of land-grant colleges and state game departments throughout the country. He was also one of the sponsors of the 2900-acre Patuxent Research Refuge near Laurel, Maryland. Other outstanding accomplishments that brought him inter-

national recognition included his contributions to the development of methods for censusing migratory bird populations, his successful efforts in the introduction of musk oxen from Greenland into Alaska, and his administrative direction of reindeer investigations in the Territory of Alaska. He authored many State and Federal biological reports, magazine articles, and other publications on the life history and habits of birds and mammals.

His scientific affiliations were: Fellow of the American Association for the Advancement of Science; Charter member of the American Society of Mammalogists; member of the American Forestry Association, the Society of American Foresters, the Washington Academy of Science, the Wildlife Society, the University Club of Washington, D. C.; an associate member of the American Ornithologists' Union, and memberships in Sigma Xi, Alpha Zeta, and Sigma Alpha Epsilon. He was past president of the Washington Biological Society and a member of the Stansbury Masonic Lodge of Washington, D. C.

Doctor Bell is survived by his widow, the former Clara Carlton Preston; a son, Comdr. David Bonar Bell, U. S. Navy, of Annapolis, Maryland, and a daughter, Mrs. Julia Carlton Edwards. The family residence is at 803 Rittenhouse St., N. W., Washington, D. C.

Funeral services were held at 2:00 P. M., April 1, in the Trinity Episcopal Church, Washington, D. C. Interment was private at Elkader Cemetery, Elkader, Iowa.—VIOLA S. SCHANTZ, *Fish and Wildlife Service, U. S. Department of the Interior, Washington, D. C.*

DEATHS REPORTED

Deaths of the following members have been reported: **Frederick M. Dille,** Nogales, Arizona, January 24, 1950: **Arthur H. Helme,** Port Jefferson, New York, 1949; **Victor E. Jones,** Idaho State College, August 24, 1949; **Gayle Pickwell,** San Jose, California, May 29, 1949; **Walter B. Sheppard,** Denver, Colorado, 1949; **Rudolf Bennitt,** Columbia, Missouri, February 2, 1950; **E. C. Cross,** Toronto, Ontario, 1950.

DATE OF ISSUE OF PREVIOUS NUMBER

Vol. 31, No. 2, Journal of Mammalogy, Mailed **May 25, 1950**